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172

HARMSWORTH SELF-EDUCATOR

1906

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A KEY TO THE HARMSWORTH SELF-EDUCATOR

At the heading of each article in the SELF-EDUCATOR is the number of the group to which the article belongs, and a reference to this key indicates precisely the place of the article in the scheme of the book. This key, therefore, enables the student at any time to understand what has preceded and what is to follow any part of the work to which he may happen to turn.

GROUP 1.

Agriculture. Beekeeping. Gardening.

FARMING. In all its Branches. Dairying. Poultry.
BEEKEEPING. A Practical and Commercial Course.
GARDENING. How to Get the Most out of a Minimum of Land. Gardening for Pleasure and Profit. Market Gardening.

GROUP 2.

Art. Architecture. Glass. Earthenware. Carving.

ART. Theory and Training. Painting. Sculpture. Architecture (Theory. Styles. Practical Training). History and Ideals of Art.
GLASS AND EARTHENWARE. Including Pottery.
CARVING. Wood. Bone. Ivory. Horn Tortoiseshell.

GROUP 3.

Biology. Psychology. Sociology. Logic. Philosophy. Religion.

BIOLOGY. Including Evolution, Palæontology. Heredity, Anthropology, Ethnology.
PSYCHOLOGY. Including Psychical Research.
SOCIOLOGY. Including Political Economy.
LOGIC. The Science of Reasoning.
PHILOSOPHY. Systems of Thought.
RELIGION. History and Systems. Christianity.

GROUP 4.

Building. Cabinet Making. Upholstering. Fire.

BUILDING. Excavating. Drainage. Manufacture of Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smiths' Work. Painting, Paperhanging and Glazing, Heating, Lighting, and Ventilation. Building Regulations. Quantity Surveying. Building Abroad. In Business as a Builder.
CABINET MAKING AND UPHOLSTERING. A Practical Course.
FIRE. Fireproof Materials. Fire Prevention. Fire Extinction.

GROUP 5.

Chemistry and Applied Chemistry.

CHEMISTRY. Inorganic and Organic. Chemistry of the Stars.
APPLIED CHEMISTRY. Acids and Alkalies. Oils (Fixed Oils and Fats; Waxes; Essential Oils and Perfumes; Paints and Polishes). Candles. Soaps. Glycerine. Glues and Adhesives. Starches. Inks. Tar and Wood Distillation. Matches. Celluloid. Manure. Waste Products. Petroleum. Paper Making (including Paper Staining and Uses of Paper). Photography.

GROUP 6.

Civil Service. Army and Navy.

CIVIL SERVICE. Municipal. National. Imperial.
ARMY AND NAVY. How to Enter Them.

GROUP 7.

Clerkship and the Professions.

CLERKSHIP AND ACCOUNTANCY. Complete Training. Bookkeeping.
BANKING. The Whole Practice of Banking.
INSURANCE. Life, Fire, Accident, Marine.
AUCTIONEERING AND VALUING. Practical Training.
ESTATE AGENCY. Departments and Officials of a Great Estate. Training a Land Agent.
MEDICINE. Training of a Doctor. Specialists. Veterinary Surgeons. Chemists and Druggists. Dentistry: The Dental Mechanic. Home and Professional Nursing.
CHURCH. How to Enter the Ministry of all Denominations.
SCHOLASTIC. Teachers. Professorships. Governesses. Coaches. Tutors.
SECRETARIES, etc. Institution Officials. Political Organisations. Lecturers.
LAW. Solicitors and Barristers. Personal and Commercial Law. Copyright.

GROUP 8.

Drawing and Design.

DRAWING. Freehand. Object. Geometrical. Brush. Memory. Light and Shade.
TECHNICAL DRAWING. For Engineers; Coppersmiths, Tinmen, Boilermakers; Architects; Stonemasons; Carpenters and Joiners; Plumbers.
DESIGN. Book Decoration. Illumination. Textiles. Wall Papers. Metal Work.

GROUP 9.

Dress.

DRESS. Dressmaking. Underclothing. Children's Clothing. Tailoring. Millinery. Men's Hats. Furs and Furriers. Feathers. Shirts and Collars.

GROUP 10.

Electricity.

ELECTRICITY. Electrical Engineering. Telegraphs and Telephones (including operation of). Cables and Insulated Wire. In Business as an Electrical Engineer.

GROUP 11.

Civil Engineering.

CIVIL ENGINEERING. Surveying. Varieties of Construction. Machines Employed. Roads. Bridges. Railways and Tramways. Water Supply. Sewerage. Refuse. Hydraulics. Pumps. Harbours. Docks. Lighthouses. Foreign Work. In Business as a Civil Engineer.

GROUP 12.

Mechanical Engineering. Military Engineering. Arms & Ammunition.

MECHANICAL ENGINEERING. Applied Mechanics. Workshop Practice. Tools (Hand and Miscellaneous. Machine Tools. Portable Machine Tools). Machines and Appliances (A General Guide to Construction. Clocks and Watches. Scientific Instruments).
MILITARY ENGINEERING. Pontoons. Bridges. Fortifications. Rafts. Trenches. Passing Rivers. Conditions in Peace and War.
ARMS AND AMMUNITION. Manufacture of Arms and Explosives.

GROUP 13.

Geography. Astronomy.

GEOGRAPHY. Physical. Political. Human. Commercial.
ASTRONOMY. A Survey of the Solar System.

GROUP 14.

Geology. Mining. Metals and Minerals. Gas.

GEOLOGY. The Making of the Earth.
MINING. The Practice of Mining: Coal, Gold, Diamonds, Tin, etc.
METALS. Metallurgy. Iron and Steel. Iron and Steel Manufactures. Metal Work. Cutlery.
MINERALS. Mineralogy. Properties of Minerals.
GAS. Manufacture of Gas.

GROUP 15.

History.

A Short History of the World from the Beginning.

GROUP 16.

Housekeeping and Food Supply.

SERVANTS. Qualifications and Duties of Every Kind of Servant.
COOKERY. A Practical Course, with Recipes.
LAUNDRY WORK. Washing. The Laundry as a Business.
FOODS AND BEVERAGES. Milling. Bread-making. Biscuits and Confectionery. Sugar. Condiments. Fruit. Fisheries. Food Preservation. Catering. Brewing. Wines and Ciders. Mineral Waters. Tea. Coffee. Chocolate. Cocoa.

GROUP 17.

Ideas. Patents. Applied Education.

IDEAS. The Power of Ideas in Life. Brains in Business.
PATENTS AND INVENTIONS. How to Protect an Idea.
APPLIED EDUCATION. Application of Education in Daily Life. Finance.

GROUP 18.

Languages.

How to Study a Language. Courses in Latin, English, French, German, Spanish, Italian, Esperanto, Greek. A Table of Root Words.

GROUP 19.

Literature. Journalism. Printing. Publishing. Libraries.

LITERATURE. A Survey of the World's Great Books and their Writers. Poetry. Classics. Fiction. Miscellaneous. How to Read and Write.
JOURNALISM. A Guide to Newspaper Work, with Practical Training.
PRINTING. Composing by Hand and Machine. Type Cutting and Founding. Engraving and Blocks. Bookbinding and Publishing.
LIBRARIES. Officials and Management of Libraries.

GROUP 20

Materials and Structures. Leather. Wood Working.

MATERIALS. The Characteristics and Strength of Materials.
STRUCTURES. The Stability of Structures.
LEATHER. Leather Industry. Leather Belts. Boots and Shoes. Saddlery and Harness. Gloves. Sundry Leather Goods.
WOOD WORKING. Design and Operation of Wood Working Machinery. Wood Turning. Miscellaneous Woodwork.

GROUP 21.

Mathematics.

MATHEMATICS. Arithmetic. Algebra. Geometry. Plane Trigonometry. Conic Sections.

GROUP 22.

Music. Singing. Amusement.

MUSIC. Musical Theory. Tonic Solfa. Tuition in all Instruments. Orchestration. Conducting. Bell Ringing. Manufacture of Musical Instruments.
SINGING. The Voice and Its Treatment.
AMUSEMENT. Drama and Stage, including Elocution. Business side of Amusement. Sports Officials.

GROUP 23.

Natural History. Applied Botany. Bacteriology. Natural Products.

NATURAL HISTORY. Botany: Kingdom of Nature—its Marvels, Mechanism, and Romance; Flowers, Plants, Seeds, Trees, Ferns, Mosses, etc. Zoology: Animals, Birds, Fishes, Reptiles, Insects.
APPLIED BOTANY. Tobacco & Tobacco Pipes. Forestry. Rubber and Gutta Percha. Basket and Brush Making. Cane Work. Barks (Cork, Wattle).
BACTERIOLOGY. Pathological and Economic.
NATURAL PRODUCTS. Sources. Values. Cultivation.

GROUP 24.

Physics. Power. Prime Movers.

PHYSICS. A Complete Course in the Science of Matter and Motion.
POWER. A General Survey of Power. Natural Sources. Liquid and Compressed Air.
PRIME MOVERS. Engines. Steam. Gas. Heat. Turbines. Windmills.

GROUP 25.

Physiology. Health. Ill-health.

PHYSIOLOGY. Plan of the Body. Digestive. Circulatory. Respiratory, Locomotor and Nervous Systems. The Senses.
HEALTH. The Five Laws of Health. Personal Hygiene. Environment. State Medicine and the Public Health.
ILL-HEALTH. General Ill-health. Its Special Forms. Common Ailments and Domestic Remedies.

GROUP 26.

Shopkeeping. Business Management. Publicity.

SHOPKEEPING. A Practical Guide to the Keeping of all Kinds of Shops.
BUSINESS MANAGEMENT. The Application of System in Business.
PUBLICITY. Advertising from all Points of View As a Business.

GROUP 27.

Shorthand and Typewriting.

SHORTHAND. Taught by Pitmans. TYPEWRITING. Working and Management of all Machines.

GROUP 28.

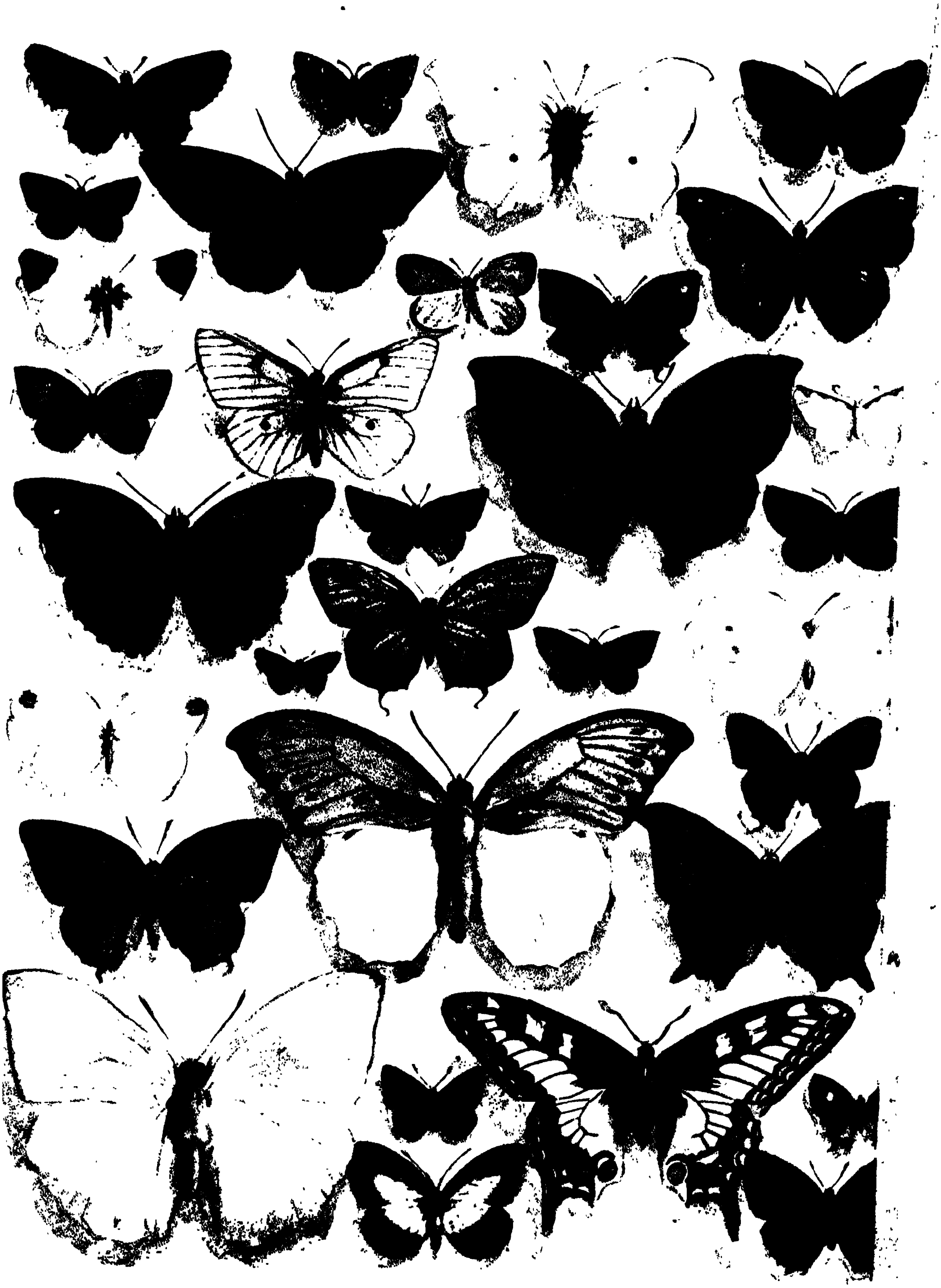
Textiles and Dyeing.

TEXTILES. The Textile Trades from Beginning to End.
DYEING. Dyes and Their Application.

GROUP 29.

Travel and Transit.

TRAVEL. How to See the World. The Business Side of Travel.
TRANSIT. A General Survey of Means of Communication.
VEHICLES. Construction of Air, Land and Sea Vehicles. Business of a Liveryman, Carrier, etc. Driving.
RAILWAYS. The Management and Control of Railways.
SHIPS. Shipbuilding. Shipping. Management of Ships.



BUTTERFLIES IN THEIR NATURAL COLOURS

[See NATURAL HISTORY]

EVERY·DOOR·IS·BARR'D·WITH·GOLD·AND·OPENS·BUT·TO·GOLDEN·KEYS

HARMSWORTH SELF-EDUCATOR

A·GOLDEN·KEY
TO·SUCCESS·IN·LIFE

EDITED·BY·ARTHUR·MEE

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CONTENTS OF THIS VOLUME

THE STATE LADDER OF LEARNING

OPPORTUNITIES FOR GIRLS IN THE BRITISH ISLES

By W. H. Stuart Garnett

[illegible] only of late years been fully appreciated [illegible] British nation that the education of [illegible] matter of no less importance to the [illegible] that of men. England has, perhaps, [illegible] longer time to realise this truth than [illegible] sister kingdoms, and it was not until [illegible] had been made—by the Act of 1870—for the elementary education of children of both sexes on equal terms that any really serious attention was devoted to the secondary education of the daughters even of those parents who spent large sums to secure a public school education for their sons.

The somewhat tardy recognition of the need was, however, followed by strenuous endeavours for its relief, and the outburst of energy in the matter of providing schools for girls which marked the latter half of the nineteenth century has made it possible to say that an excellent elementary and secondary education is now within the reach of every girl in the United Kingdom, and that a university career is open to girls of talent and determination. The conditions governing the education of girls in the countries of the United Kingdom vary considerably, on account both of the diverse legislative enactments on the subject now in force, or recently abrogated, and of the variations of the social conditions in the different districts.

The Mediæval System. In England, more than in the sister kingdoms, the conditions of education of boys and girls are markedly differentiated by reason of the disparity in the endowments devoted to the support of educational institutions for the youth of either sex. This disparity is no doubt due to the tradition that girls should be trained at home, a tradition dating back to the fourteenth century, when the [illegible] plied her [illegible] staff under her mother's eye, while her brother studied the courtly virtues in the castle of his lord, until in due time his [illegible] conferred on him the knightly accolade [illegible] of the more modern diploma or degree. The tradition has come down to modern times, and the girl of to-day suffers from the prejudice of pious founders of the Middle Ages, [illegible] their ungallant devotion of their funds to the exclusive use and maintenance of the youth of their own sex. On the other hand, the girls' [illegible] from the mediæval traditions which [illegible] public schools of Great Britain. The [illegible] smaller expenditure of the girls' school on [illegible] and playgrounds and the lower salary [illegible] by the schoolmistress than by the schoolmaster combine to reduce the cost of [illegible] education, and to compensate the dis[illegible] of girl students arising from lack of [illegible] endowments. The paucity of en[illegible] schools has itself, to some extent, [illegible] the cause of education. It has been [illegible] boys' schools, when the property [illegible] company or individual owner, to compete with the large and wealthy institutions with which England abounds. The private school has nearly always succumbed, and the consequent absence of serious competition has made possible the survival, in public schools, of mediæval and unsatisfactory methods of education. It may therefore be said that, so far at least as scientific and methodical teaching is concerned, the education in the first grade girls' schools of England is at least as good as that obtainable in the venerable institutions where the boys of the country are trained in the way they should go.

The State School System. In Scotland and in Wales, secondary education has been for some time, as it now is in England, the duty of the local education authorities. Secondary schools are conducted in Wales by the county councils, and in Scotland by the school boards, and conducted with excellent results. We have not, in the appended tables, mentioned any but the largest of the Welsh mixed county schools, and of the high schools in Scotland. All of these may, however, be trusted to furnish an exceedingly good education at a low cost to the parent. The county schools now being started in various parts of England have not been included, partly for the reason that it is difficult to estimate fairly the merits of institutions so new as to be almost experimental, and partly because the numerous and excellent girls' schools established in England, before the Education Act of 1903 enabled the county councils to build and maintain the present county schools, render the latter a much less essential part of the scheme of national education in England than of the Welsh or Scottish scholastic system.

Education of Girls in Ireland. The conditions of education in Ireland are very much the same for girls and for boys. State aid is granted to all efficient secondary schools, largely on the results of examination of the scholars. The principal Protestant secondary schools are the property of companies or of private individuals, very much as in England. On the other hand, the education of girls belonging to the Catholic Church, like that of the boys, is principally in the hands of religious societies. The Ursuline order deserves special credit for its excellent educational work.

The teaching of children by members of a sisterhood, who work without remuneration, makes it possible to obtain an excellent education at a cost phenomenally low. There is probably no part of the British Isles where so good an education is within the reach of the very poor as in the south of Ireland. On the other hand, while the merits of the system are worthy of attention, it must be recognised that it has the effect of inducing a number of the pupils—and these commonly the ablest and best girls in the school—to take the vows of celibacy, a condition

[illegible] articles on pages 481 and 1777.

LEADING SECONDARY SCHOOLS FOR GIRLS IN ENGLAND

COUNTY.	SCHOOL.	ANNUAL FEES. Day Pupils.	ANNUAL FEES. Boarders.	NUMBER AND ANNUAL VALU[E] SCHOLARSHIPS ANNUALLY AWA[RDED] At School.	NUMBER AND ANNUAL VALU[E] SCHOLARSHIPS ANNUALLY AWA[RDED] After Leav[ing]
Bedfordshire ..	Bedford High School	£9—£12	£65—£80	3 free	£25, £35,
	Bedford Modern School	£4	£45	1 free	1 free to [illegible] Schoo[l]
Berkshire ..	Reading High School	4½—15 gs.	64½—75 gs.	None	None
Buckinghamshire	Wycombe Abbey School	None	£105—£120	3 of £30	No[ne]
Cambridgeshire	Perse High School for Girls, Cambridge	£6—£15	36—50 gs.	None	2 of £37. 10 for 3 years
Cheshire ..	Birkenhead High School	10 gs. to £16. 10	None	1 of £15	None
	Queen's School, Chester	£9—£16	£56—£68	9 free	1 of £[illegible]
	High School, Macclesfield	3—10 gs.	None	3 of fees	None
Cornwall ..	High School, Truro	4½—16½ gs.	None	None	Non[e]
Cumberland ..	Carlisle High School	10 gs. to £16. 10	None	1 of £15	None
Derbyshire ..	Derby High School.. .. .	9—15 gs.	£50	3 of £10	None
Devonshire ..	Exeter High School	6 gs.—£15	56—64 gs.	None	None
	Plymouth High School	12—18 gs.	60—66 gs.	None	None
	Devonport High School . ..	9—15 gs.	£47. 5	..	..
Durham ..	Gateshead High School .	10 gs. to £16. 10	None	1 of £15	Occasional 1 of £10
Gloucestershire	Cheltenham Ladies' College	12—24 gs.	62—94 gs.	1 of £25	1 of £25—£4[illegible] and others
	Clifton High School ..	£12—£24	£77—£89	None	None
	Redland High School, Bristol .	9—15 gs.	49—58 gs.	4 of £15 and others	None
Hampshire ..	Bournemouth High School ..	2—6 gs.	48 gs.	11 of £5—£30	Biennially £30
	Winchester High School	7½—18 gs.	16½—57½ gs.	Some 15—50 gs. for boarders only	1 of £40
	Portsmouth High School	10 gs to £16. 10	None	1 of £15	None
Herefordshire..	Hereford High School . ..	6—15 gs.	42—57 gs.	None	None
Hertfordshire..	Berkhamsted High School ..	£8—£10	£58—£60	4, part or whole fees	None
	Church High School, St. Albans ..	9—18 gs.	None	None	None
	Christ's Hospital, Hertford ..	None	A free boarding school	None	None
Kent	Girls' Grammar School, Rochester	£8—£10	None	Several free	None
	Tunbridge Wells High School .	10 gs. to £16. 10	None	1 of £15 and 1 of £4	None
Lancashire ..	Bolton High School	6—15 gs.	None	None	Biennially 1 of £35
	Merchant Taylors' Girls' School, Gt. Crosby	£8—£10	£22—£40	Several free	1 of £40
	East Liverpool High School ..	10 gs. to £16. 10	None	1 of £15	None
	Liverpool Inst. High School for Girls	£4. 16 to 9 gs.	None	Several free	1 of £36
	Liverpool High School	10 gs. to £16. 10	None	1 of £15 and 1 of £5	Triennially 1 of £40
	Manchester High School for Girls	12 gs.	£57 12	18 free	6 of £26—£50
Leicestershire..	Wyggeston Girls' School, Leicester	£5—8—£9	None	30 free	£50 and £30
Lincolnshire ..	Girls' High School, Lincoln ..	£5—£8	£33—£49	20 of £10	1 of £100
London ..	North London Collegiate School for Girls, Camden Town	18 gs.	51—63 gs.	12 of £20 and 4 of £10	1 of £50
	The Camden School for Girls ..	9 gs.	..	6 of £15—£20	2 of £20
	Blackheath High School	10 gs. to £16. 10	..	2 of £15	None
	Haberdashers' School, Acton ..	5—9 gs.	..	Numerous, 14 gs., etc.	Variable, £30 t[o] £80
	Mary Dachelor Girls' School, Camberwell	10 gs.	46 gs.	8 free, 3 of £20 and others	3 of £20 and occasionall[y] 1 of £50
	Central Foundation School for Girls, Bishopsgate	3 gs.—£5	..	Numerous free and others	2 of £50
	City of London School for Girls, Embankment	9—12 gs.	..	7 of 10 gs.—£40	2 of £50

LEADING SECONDARY SCHOOLS FOR GIRLS IN ENGLAND—continued

COUNTY.	SCHOOL.	ANNUAL FEES.		NUMBER AND ANNUAL VALUE OF SCHOLARSHIPS ANNUALLY AWARDED	
		DAY PUPILS.	BOARDERS.	AT SCHOOL.	AFTER LEAVING.
London—contd.	Clapham High School	10 gs. to £16. 10	..	2 of £15 and others	None
	Dulwich High School	10 gs. to £16. 10	..	2 of £15 and 2 free	None
	James Allen's School, Dulwich ..	8 gs.	..	5 of £13. 8	None
	Roan School, Greenwich	6 gs.	None	Numerous	1 of £45 for 3 years
	Lady Holles' School, Hackney ..	£4—£6	..	3 free	Variable, £30 to £50
	St. Paul's Girls' School, Hammersmith	£21	£66	39 free	Variable
	Hampstead High School	10 gs. to £16. 10	..	1 of £15	None
	Aske's School, Hatcham	6–9 gs.	..	1 of £20 and many others	Variable
	Dame Owen's School, Islington ..	10 gs. to £16. 10	..	1 of £15	None
	Maida Vale High School, Elgin Avenue	10 gs. to £16. 10	None	..	..
	St. Mary's College, Paddington ..	10—24 gs.	£75	1 of £30 for 2 years	None
Some other schools in the London County Council area are placed under their Counties	Putney High School	10 gs. to £16. 10	.	1 of £15	None
	St. Saviour's and St. Olave's Grammar School for Girls, Southwark	£6	Boarding houses licensed by the Council are attached to many of the High Schools	£13, £18, and usual £10	Variable
	Skinners' School for Girls, Stamford Hill	6—9½ gs.		Numerous	1 of £50
	Streatham Hill High School ..	10 gs. to £16. 10		1 of £15 and 1 of 7½ gs.	None
	Sydenham High School . .	10 gs. to £16. 10		1 of £15	None
	Grey Coat Hospital, Westminster	5 gs. to £6. 15		Largely free	1
	Coborn School for Girls, Bow ..	4 gs.–£6		Numerous free	4 of £20–£30
Middlesex .	High School for Girls, Tottenham	6–12 gs.	None	Some free	Various, under revision
Norfolk ..	Norwich High School .. .	10 gs. to £16. 10	None	1 of £15	None
	Thetford Grammar School ..	£6	£41	8 of £6	None
Northamptonshire	The High School, Northampton .	£5. 14 to £7. 16	None	None	None
Northumberland	Central Newcastle High School for Girls	10 gs. to £16. 10	None	1 of £15	None
Nottinghamshire	Queen Elizabeth's Grammar School for Girls, Mansfield	6 gs.–£8	30–45 gs.	8 of half fees	1 of £20
	Nottingham High School .. .	10 gs. to £16. 10	None	1 of £15	None
Oxfordshire ..	Queen Anne's School, Caversham	£9—£12	£33–£40	Numerous	Variable
	Oxford High School .. .	10 gs. to £16. 10	None	1 of £15 and 1 of £10	None .
Salop	Shrewsbury High School . ..	10 gs. to £16. 10	None	1 of £15	None
Somersetshire	Bath High School	10 gs. to £16. 10	None	1 or 2 of £15	None
Staffordshire .	High School, Burton-on-Trent .	£8	None	2 free	1 of £50
	Croft School, Betley .	None	100 gs.	None	None
Suffolk ..	Endowed School for Girls, Ipswich	£5–£6	£24. 10 to £27	15 free	2 of £10–£20
	St. Felix School, Southwold ..	21–27 gs.	£99–£105	None	None
Surrey .	Croydon High School . .	10 gs. to £16. 10	None	1 of £15	Triennially 1 of £30
	The High School for Girls, Guildford	9–15 gs.	None	None	None
	Tiffin's Girls' School, Kingston-on-Thames	£6	None	Occasional	None
See also under London	The High School, Surbiton	9–15 gs.	None	None	None
	Sutton High School	10 gs. to £16. 10	None	1 of £15 and 1 of £5	None
	Wimbledon High School	10 gs. to £16. 10	None	3 of £15 and 1 of £10	None
Sussex ..	Roedean School, Brighton ..	None	£130	1 of £80 and others	None
Warwickshire ..	Edgbaston High School for Girls, Birmingham	12—18 gs.	£66–£72	2 of £4. 10—£8	None
	The King Edward's Grammar Schools, Camp Hill, Aston, and Bath Row, Birmingham	£4. 10	None	4 of £6—£12	1 of £30

LEADING SECONDARY SCHOOLS FOR GIRLS IN ENGLAND—continued

COUNTY.	SCHOOL.	ANNUAL FEES.		NUMBER AND ANNUAL VALUE OF SCHOLARSHIPS ANNUALLY AWARDED.	
		DAY PUPILS.	BOARDERS.	AT SCHOOL.	AFTER LEAVING.
Warwickshire ..	King Edward's High Schools, New Street, and Summer Hill, Birmingham	£12	None	4 of £10—£20	1 of £50
	The King's High School, Warwick	£5—£8	£50—£53	Several free	1 of £50
Westmorland ..	The High School, Kendal	9—15 gs.	None	None	None
Wiltshire ..	Godolphin School, Salisbury	12—18 gs.	£75—£95	6, part fees	None
Worcestershire	Worcester High School for Girls	9—15 gs.	None	3 of £15 and others	1 of £40
Yorkshire ..	Barnsley High School for Girls ..	£7. 10	None	County schools only	
	Bradford Girls' Grammar School	6—15 gs.	None	Some free	Variable
	Leeds High School	6—18 gs.	..	18 gs., £5—£10 and others	None
	Sheffield High School . ..	10 gs. to £16. 10	None	2 of £15	None
	Grammar School for Girls, Skipton-in-Craven	£6—10 gs.	£45—£49	Several half fees	None
	Wakefield High School	£6—£12	£40—£50	12 of half fees	2 of £50
	York High School	10 gs. to £16. 10	None	1 of £15 and some free	None
	The Mount, York	None	57 gs—63 gs.	Restricted	..

LEADING SECONDARY GIRLS' SCHOOLS IN SCOTLAND, IRELAND, & WALES

COUNTY.	SCHOOL.	DAY PUPILS.	BOARDERS.	AT SCHOOL.	AFTER LEAVING.
SCOTLAND					
Edinburgh ..	Edinburgh Ladies' College ..	2¼ gs.—£12	None	Very numerous and valuable	1 of £25 and others
	George Watson's Ladies' College	Ditto.	Ditto.	Ditto.	Ditto.
	St. George's High School	10½—22½ gs.	None	None	None
St. Andrews ..	St. Leonard's	15—27 gs.	£82—£112	6 of £20	1 of £30 and others
Glasgow ..	Garnethill High School .	£1. 10—6 gs.	None	20 free	None
	Hutcheson's Girls' Grammar School	£1. 10—£6	None	Very numerous	Several of £10
Aberdeen ..	The High School	£2—£8	None	2 of £12	1 of £10
IRELAND					
Dublin	Alexandra School	£9—£11	£57—£69	4 of £10	2 of £10
	Alexandra College	£17—£24	£82	17 of £10	1 of £10
Cork	St. Angela's High School . ..	£3. 2—6 gs.	None	None	1 of £20
	Ursuline Convent, Blackrock ..	None	£30—£33	None	1 of £20
Belfast ..	Victoria College	4—12 gs.	£35—£48	None	None
Londonderry ..	Strand House School	2—8 gs.	£32—£40	Several £8—£9	1 of £105; 2 of £300 and £90
Monaghan ..	St. Louis Convent	8 gs.	£20	3 of £15—£30	
WALES					
Denbighshire ..	County School, Wrexham .	7 gs.	£31. 7	Several free	..
Glamorganshire	High School for Girls, Swansea .	£6. 10	£38	Several free and others	Triennially 1 of £25
	Howell's School, Llandaff . ..	£8	£28	7 of £28 and others	Several of £40
	County School, Gelligaer	£4	None	Numerous free	None
Monmouthshire	Intermediate School, Cardiff ..	£7. 10	£49. 10	26 of £3. 15, and 24 of £17. 10	5 of £20
	Intermediate School, Newport ..	£9	None	County scholarships	1 of £20
	County School, Pontypool ..	£4. 10	£30	£5, part fees	..
Montgomeryshire	County School, Newtown	5 gs.	None	11 of 5 gs	None

which can only be deplored in the interests of the nation.

The universities of Scotland, Ireland and Wales now place women students on the same footing as men, so that it is unnecessary to add anything here to what we have already said on the subject of university institutions in these parts of the Kingdom [see page 1782]. The same course is adopted by the more recently constituted universities of England, but the older universities still decline to admit women to membership, or to confer degrees upon them. Oxford and Cambridge have, however, so far moved with the times as to permit women students of the neighbouring

LEADING SCHOOLS OF DOMESTIC ECONOMY AND COOKERY IN ENGLAND

School.	Annual Fee.	Remarks.
London:		
Battersea Polytechnic	£3—£55	Day classes
South-Western Polytechnic, Chelsea	5s.—£3	..
Northern Polytechnic, Islington	£24	Day classes only
Norwood Technical Institute, Lambeth	£1	..
Northampton Institute...	Low	Day school only
Paddington Technical Institute	30s.—£3	..
Shoreditch Technical Institute	30s. £3	..
National Training School of Cookery, Westminster	6d. £40	A school for artistic work
Provinces:		
Dorset School of Domestic Economy and Cookery, Dorchester ..	½—1½ gs. per subject	Boarders £30
Municipal School of Technology, Manchester	1—5 gs. per subject	..
Harris Institute, Preston	2s. 6d. 5 gs.	Day classes
School of Domestic Science, Liverpool	Low	..
School of Science and Art, Chester	3s. 6d. 8s. 6d.	Day classes
School of Domestic Economy, Exeter	½ 2 gs.	..
Gloucester School of Domestic Science, Gloucester	Low	..
Municipal School of Domestic Science, Bristol	15 30 gs.	..
Springhill Domestic Economy School, Bromley	Free	Day classes
Shropshire Technical School for Girls, Radbrook	£40 £60	A boarding college
Northern Counties Training School of Cookery, Newcastle-on-Tyne	£7 £30	..
Northamptonshire School of Domestic Economy	Low	..
Municipal School of Science and Technology, Brighton	15s. 15 gs.	Day classes
Training School for Teachers, Birmingham	11 gs. £20	Day classes
Municipal Technical School, Halifax	1½ 12 gs.	
Municipal Technical School, Hull	3 15 gs.	Day classes
Technical College, Huddersfield	½ 1½ gs.	..

UNIVERSITY COLLEGES FOR WOMEN IN ENGLAND

In Scotland, Ireland and Wales Universities are open to both sexes, as also some newer universities in England

Town.	College.	Fees.	Minimum Cost.	Scholarships.
Oxford	Somerville College ..	£87 £93	£100 £110	Several of £25-£50
	Lady Margaret Hall ..	£93 £103	£110 £115	4 of £25 £50
	St. Hugh's Hall	£93 £103	£110	1 of £35
	St. Hilda's Hall	£93 £101	£110	2 of £30 and £40
Cambridge ..	Newnham College . ..	£90 £105 Out-students, £36	£100 £115	6 of £50 and others
	Girton College . ..	£105	£110 £125	6 of £30 £60, occasionally £88
Englefield Green	Royal Holloway College ..	£90	£110	25 or more of £30—£60
London . ..	Bedford College	£89 5 £121. 15 Course from 4½ gs.	£100 £120	Under revision

colleges and halls, here set out, to sit for the university examinations, and to appear side by side with the graduates in the resulting lists.

It will be noticed that, in spite of the endowments of the men's colleges, it has been found possible to provide university education for women at a lower cost than that at which it is available to men. Holloway College for women is richer in scholarships in proportion to the number of the students than are any of the ladies' colleges at Oxford and Cambridge, and compares very favourably with the older institutions of these universities. On the whole, although the smaller number of institutions open to women makes it a little harder for them to procure a free university education than it is for men, still the competition is less—a university career is attractive only to the minority, and for the majority ample provision is made in the domestic economy schools set out in the table—so that it is fair to say that such a career is now open to every girl who is willing to make some effort for the realisation of her ambition.

BEETLES, MOTHS, & BUTTERFLIES

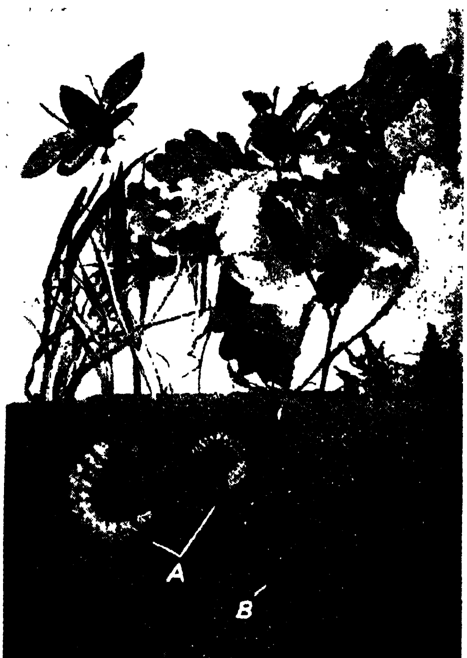
The Life Histories of Insects—continued. Beetles, Butterflies and Moths. Protective and Warning Colouration. Mimicry. Courtship Dress. Caterpillars

By Professor J. R. AINSWORTH DAVIS

Insects—continued

6. Beetles. [See Plate facing page 3361.] These include an enormous host of insects, something like 150,000 species having been described. Their horny investment is particularly thick, and they possess strong biting jaws, though these differ in some respects from those described for the cockroach and its allies. The third pair, for instance, are much more intimately fused together into a lower lip. The fore-wings are modified into hard wing-covers, while the hind-wings are membranous, as in straight-winged insects (cockroaches, grasshoppers, etc.). But there is one marked difference between the two orders in regard to these organs. The hind-wings of the latter fold up along a set of longitudinal pleats when they are tucked away under their covers, but in a beetle they are relatively long, and require a transverse fold as well.

The life history of beetles exhibits a well-marked metamorphosis. From the egg a grub hatches out, which, after a time, passes into a motionless pupa stage, and ultimately the investment of this splits open so that the perfect insect may emerge [431].



431. LIFE HISTORY OF A COCKCHAFER
a. Grubs *b.* Pupa
(Photograph by Prof. B. H. Bentley)

Stag Beetles. Stag beetles [Plate facing page 3361] are so named from the antler-like appearance of the huge mandibles in the male, though these formidable-looking structures do not appear to be used as weapons. Perhaps they are courtship ornaments. The family includes our largest native species, *Lucanus cervus*, the larva of which lives for some four years in rotten wood or among the roots of trees before becoming a pupa.

Chafers. Chafers include dung-beetles, cockchafers, hercules beetles, and rosechafers. Perhaps the most interesting dung-beetles are the scarabs (*Scarabæus*), of which one species was sacred in Egypt. Their fore-legs are broadened into powerful digging organs [435], with which they excavate subterranean chambers that serve as larders for the storage of balls of dung, and also as nurseries, the eggs being laid in masses of the same unsavoury material. Among cockchafers, the common species, *Melolontha vulgaris* [431], greatly damages the leaves of trees during its adult stage, while the larva devours roots during its underground life, which lasts from three to five years in different localities under varying circumstances. The hercules beetles and their allies are remarkable as being among the largest insects, and also on account of the curious horn-like projections on the body of the male. Rosechafers are beautiful insects of a metallic green colour [Plate facing page 3361].

Tiger Beetles. These are highly predaceous forms, most of which live in the warmer parts of the world. The larvæ dig vertical burrows and patiently lie in wait for prey, with only the front part of the body projecting [432]. Ground beetles make up an extremely large family of mainly predaceous species, which mostly live on the ground and fly reluctantly. In some tropical forest-regions however—*e.g.*, parts of South America—they have taken to an arboreal life, probably in the endeavour to escape the ravages of ants. Others, again, are blind cave dwellers. The little bombardier beetle (*Brachinus crepitans*) is so named because, when chased by an enemy, it can eject a volatile fluid of acrid nature, which evaporates so as to look like a little puff of smoke [437]. A slight explosive sound is heard at the same time.

Some Water Beetles. Water-beetles [Plate facing page 3361] are carnivorous types which have become adapted to life in fresh water, although the adults have not lost the power of flight. In our native great water-beetle (*Dytiscus marginalis*) the large hind-legs are fringed with bristles and serve as oars, while air can be stored under the wing-covers. The unattractive-looking larvæ [434] both pierce and suck their prey by means of the large first jaws (mandibles), which are traversed by canals. Whirligig

beetles are also aquatic, spinning round and round by means of their second and third pairs of legs, which are broadened into beautifully-constructed paddles. Some of the water-lovers (*Hydrophilidæ*) are also aquatic, the best known being the great black water-beetle (*Hydrophilus piceus*), our largest native fresh-water form, which surrounds its eggs with a pear-shaped silken cocoon [**433**]. The adult is not a particularly good swimmer, and carries the air necessary for breathing partly under the wing-covers and partly sticking to the hairy under-surface of the body.

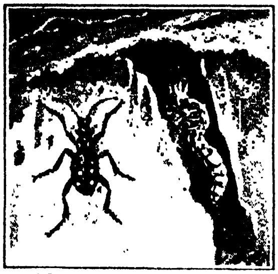
Carrion Beetles. Among the carrion beetles, the eggs are deposited in the dead bodies of various small animals. Burying beetles (*Necrophorus*) dig away the earth from under carcases used for this purpose, and ultimately succeed in entirely removing them from sight. Many members of the family are blind cave-dwellers. The rove-beetles possess very short wing-covers, and usually an elongated abdomen, which can be turned up like the tail of a scorpion in the familiar devil's coach horse (*Ocypus olens*), and is used for folding the hind-wings. Many species of the family live in ants' nests, and more will be said about them elsewhere.

Ladybirds. The pretty little ladybirds, red in colour with black spots, lay their eggs on various plants, and the larvæ which hatch out devour plant-lice, scale insects, and other pests, in a wholesale manner. The adults are unusually free from the attacks of insectivorous animals, probably owing to their unpleasant odour and taste, properties which are correlated with the conspicuous "warning" colouration.

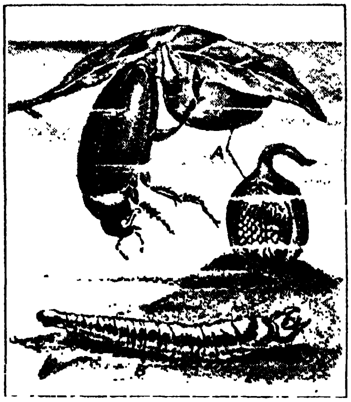
While the members of the last family are friends to the human species, exactly the opposite is true of the small beetles called *Dermestids*, widely distributed forms, of which the voracious larvæ devour articles of food, clothing, etc., as in the fur beetle (*Dermestes vulpinus*), bacon beetle (*Dermestes lardarius*), and horsehair beetle (*Anthrenus fasciatus*).

The greater death-watches (species of *Anobium*) appear to make some, at least, of the mysterious tickings often heard in old houses, and the holes in worm-eaten wood are due to their ravages. One species (*Anobium paniceum*) is the insect found in weevily biscuits, but is somewhat catholic in its tastes, and in the larval stage is credited with being the "book-worm" that does so much damage in libraries.

Fireflies and Glow-worms. Fireflies and glow-worms have long attracted attention on account of the light they emit. In the Italian firefly (*Luciola italica*), the males are by far the most brilliant, and fly about together in the evening in large numbers, scintillating like so many tiny lamps. In this case there is some doubt as to the use of the illumination. The source of light in our native glow-worm (*Lampyris noctiluca*) [**436**], on the other hand, is the wingless female, which doubtless attracts a mate thereby. Probably the same is true of the railway beetle of South America, which is so called because there is a red light at each end of the



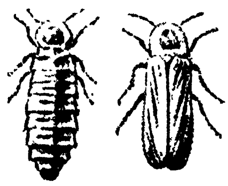
432. TIGER BEETLE AND LARVA



433. GREAT BLACK WATER-BEETLE
a. Cocoons *b.* Larva

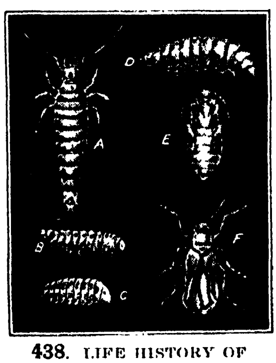
434. LARVA OF WATER-BEETLE

435. SCARAB



Female Male
436. GLOW WORM

437. BOMBARDIER BEETLE



438. LIFE HISTORY OF SITARIS
a. Larva *b.* Floating stage *c.* Resting stage *d.* Second larva *e.* Pupa *f.* Adult

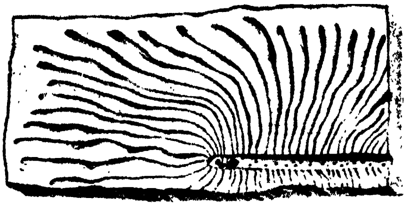
body and a series of smaller green ones along each side.

The click-beetles are able to spring in a somewhat curious way if they happen to fall on their backs, by suddenly bending the body, when a curious peg-and-catch mechanism is brought into play. The larvæ do much damage to the roots of various crops, and are known as "wire-worms" [see pages 1666–7]. Some American forms (*Pyrophorus*) give out a strong light, and are used by the natives for practical and ornamental purposes.

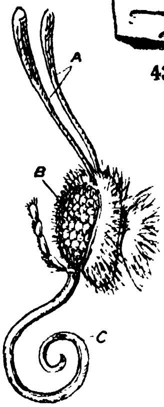
Buprestids are chiefly remarkable for the great beauty of some of the tropical species, of which the thick investments shine with a metallic lustre. Some of the bright green Indian kinds (*Sternocera*) are largely employed for decorative purposes, the wing-covers in particular being arranged in patterns on various fabrics. Quite different from these are the blackish flour-beetles, of which there is one pretty common British species (*Tenebrio molitor*), its grub being known as a "meal-worm."

Blister Beetles. These are so named because a highly-irritant substance can be extracted from their bodies—as in the typical case of Spanish fly (*Cantharis vesicatoria*), the source of cantharides. The life-history of some members of this family is extremely interesting and complex, as, for example, in one particular species (*Sitaris humeralis*) [438], which provides for its offspring at the expense of certain earth-dwelling bees (*Anthophora*). These construct a series of cells, store them with honey, deposit an egg in each, and then cover them up. Late in August the mother beetle lays her 2,000 or more eggs near the openings of the bees' nests, and some four weeks later these hatch out into little black larvæ (*a*) of peculiar appearance, which remain in a sort of winter sleep till the following April or May. They then wake up, and hold on to any hairy insects that come within their reach, most of them no doubt going fatally astray; hence the necessity for so many eggs. Let us follow the fortunes of a successful larva which has climbed on to the body of a female bee of the right species. After a time the bee will lay a floating egg in a cell previously stored with honey, and the larva seizes the opportunity to slide down on to the edible raft, which serves as a source of food for about a week.

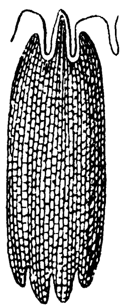
When the egg diet is exhausted, the larva sheds its skin and becomes a sort of bag (*b*) which floats about in and absorbs the honey, which provides rations for some forty days. Next follows a resting stage (*c*), which generally lasts till June of the next year, when a second larval stage (*d*) ensues, which after two days passes into a second resting stage, the true pupa (*e*). From this the perfect insect (*f*) emerges in about a month. Some individuals hurry up their development so as to become adult a year earlier.



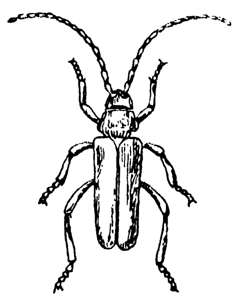
439. GALLERIES OF BARK-BEETLE



440. HEAD OF BUTTERFLY
a. Antennæ *b.* Eye *c.* Proboscis

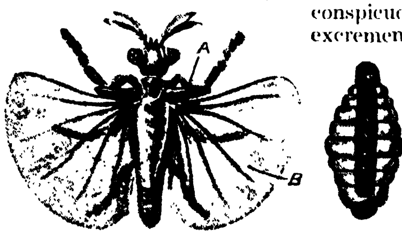


441. SCALE FROM BUTTERFLY'S WING



442. MUSK-BEETLE

Agricultural Pests. The seed-beetles are small inconspicuous forms, of which the larvæ live in peas and beans, often damaging these crops considerably. Leaf-beetles are still more notorious agricultural pests, of which the Colorado potato beetle (*Doryphora decemlineata*) has caused more than one scare in this country, while the greedy little turnip flea-beetle (*Phyllotreta nemorum*)—so named on account of its springing powers—is constantly with us (see page 1667). Here, too, are included the small flat tortoise-beetles (*Cassis*, etc.), the larvæ of which render themselves inconspicuous by heaping up their own excrements on their backs by means of a bifurcated tail acting as a dung-fork.

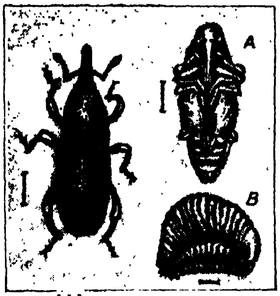


Male Female

443. STYLOPS
a. Fore-wing *b.* Hind-wing

The long-horned beetles make up a very large family of attractive-looking insects distinguished by the length of their antennæ, and include some tropical species of comparatively gigantic size. The pale grubs possess very powerful jaws, and chiefly feed on wood. Some of them have been known to live in wooden furniture for over a quarter of a century before passing into the winged adult form. One of our most elegant native species is the musk beetle (*Aromia moschata*) [442], with a metallic sheen, and with an odour which has been variously compared to roses, musk, and sweet-brier. Its larvæ live in the wood of willows.

The long-snouted vegetarian weevils include a host of small beetles, the ravages of which are only too familiar. Our native nut-weevil

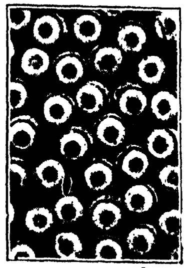


444. GRAIN-WEEVIL
. Pupa *b.* Larva

445. PRIVET HAWK-MOTH CHRYSALIS
a. Larval cast skin
(Photo. by Prof. B. H. Bentley)

Longe

446. EGGS OF SMALL TORTOISESHELL BUTTERFLY



Longe

447. EGGS OF VAPOURER-MOTH

(Magnifie eight times)

(*Balaninus glandium*), for example, deposits its eggs in hazel nuts and acorns, within which the larvæ find an abundance of nourishing food; while the larvæ of grain-weevils (species of *Calandra*) [**444**] are extremely destructive in granaries (see page 1668). The female of the birch-weevil (*Rhynchites betulæ*) is remarkable for the artistic way in which she cuts and rolls up birch leaves into elegant cases, wherein to deposit her eggs.

Bark-beetles are very destructive to the bark and wood of dead or unhealthy trees, the tunnels driven in which are arranged in characteristic ways according to the species. In a well-known British form (*Scolytus destructor*) the female bores a passage into a tree, and there lays her eggs. The larva which hatches out from each of these makes its own branch tunnel [**439**] and ultimately passes into the pupa stage, from which a perfect insect emerges. In some of these forms the food consists not so much of wood as of a sort of mould ("ambrosia"), which is said to be actually cultivated somewhat after the fashion of the mushroom-growing ants. For other insects of this nature reference should be made to the course on Forestry.

448. COCOON CONTAINING CHRYSALIS OF PUSS-MOTH
(Natural size)

Among the beetles we may perhaps include, though they are often regarded as making up a distinct order (*Strepsiptera*), the minute bee-lice (*Stylops*, etc.), which also infest wasps [**443**]. The female is simply a wingless egg-bag protruding from the abdomen of a bee or wasp, within which she is parasitic, but the male possesses well-developed hind-wings, though the front ones are reduced to mere vestiges. He leads a grown-up life of fifteen or twenty minutes, devoting it entirely to wife-hunting, courtship and mating.

7. **Butterflies and Moths.** For beauty and variety of colouration these insects are quite unrivalled, and their attractive appearance is primarily due to the fact that the four wings are covered with overlapping scales of different kinds [**441**]. The mouth parts are specialised to constitute a suctorial organ, made up of the second jaws (first maxillæ), while the first and third jaws are greatly reduced. Each second jaw has become a half-tube, and the two are hooked together to make up a proboscis, sometimes of great length, which can be separated into its halves for cleaning purposes [**440, 455**].

449. PRIVET HAWK-MOTH

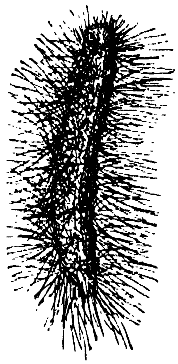
450. PRIVET HAWK-MOTH CATERPILLAR

451. MALE PUSS-MOTH
(Natural size)

(Photographs by Prof. B. H. Bentley)

The life-history exhibits a very typical and familiar metamorphosis. From the egg [446, 447], which is often beautifully sculptured, a larva known as a caterpillar [450] hatches out possessing not only the three pairs of jointed legs characteristic of the class, but also a varying number of unjointed pro-legs terminating in suckers. After feeding voraciously for some time by means of its powerful biting first jaws, and undergoing a number of moults, the caterpillar passes into the motionless pupa stage [445, 448], here called a chrysalis, which may or may not be invested in a protective cocoon. The skin of the chrysalis ultimately splits and the perfect insect makes its way out [449, 451].

Butterflies [see Plate facing page 3505] are typically distinguished from moths by the club-shaped thickenings at the ends of their antennæ, and by the fact that when settling the wings are folded together over the back. In moths the antennæ may be of various form, but very rarely club-shaped, and the rest-position of the wings is horizontal [449] or sloping downwards, while in some instances they may be more or less wrapped round the body.


452. GIPSY-MOTH CATERPILLAR

Egg-Laying Habits. The eggs are deposited on various plants, singly or in small batches, as a rule, though exceptions to this are afforded by some species, such as the tortoiseshell butterflies [446], where a large number of larvæ live together in a sort of colony. It is an extraordinary example of instinct that the mother butterfly or moth should invariably lay her eggs on plants suitable for food for the caterpillars, as her own feeding habits are entirely different. There is no maternal solicitude, except perhaps in the egger-moths and some other kinds which cover their eggs with hairs detached from their own bodies.

Caterpillars. Caterpillars make a very interesting study, their varying forms and characters being largely of protective nature; such are the numerous stiff bristles covering many of them [452], which can sometimes inflict painful or even poisoned wounds. These kinds are generally treated with respect by insectivorous birds, but cuckoos seem proof against indigestion, and eagerly snap up caterpillars which other species reject. In many instances, their colour and shading are such as to harmonise with surroundings, and make them inconspicuous, while different tints may be assumed by the same kind of caterpillar when feeding on the different food-plants which form its diet.

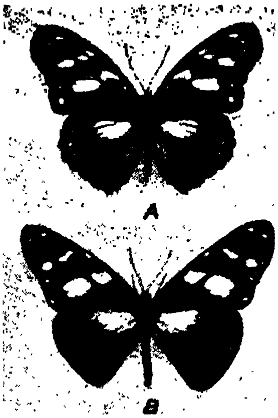

453. STICK-CATERPILLARS
(Photograph by Prof. B. H. Bentley)

Very extraordinary are the larvæ of the loopers or geometers, so called from the looping nature of their progression, due to the absence of limbs, except near the two ends of the body. They are often known as "stick-caterpillars," and when alarmed commonly hold on to twigs by means of the last pair of pro-legs (claspers), and bend out their body obliquely, so as to look like branches [453], a delusion favoured by their colour. The muscular exertion involved is in many instances relieved by the spinning of an almost invisible girdle of silk.

Warning by Colour. Some of the caterpillars which possess an unpleasant taste are extremely conspicuous, their warning colouration securing a large share of immunity from attack. A good example is afforded by the larvæ of the cinnabar-moth (*Callimorpha Jacobeæ*), which are marked with alternate black and yellow rings. It has been shown by experiment, for instance, that newly-hatched chicks reject them after the first trial, which is followed by obvious marks of distaste. After having learnt this lesson, a chick will avoid meal placed on a glass slide, to the under side of which is pasted a strip of paper painted with the cinnabar-caterpillar's coat-of-arms.

Curious warning attitudes are assumed by some caterpillars when alarmed, one of the most remarkable cases being that of the puss-moth (*Cerura vinula*) [458], which contracts its front end to look like a grotesque mask, and shoots out a pair of whip-like pink threads from the tip of its tail. It can also squirt out a highly irritant fluid from a pore below the mouth. The caterpillar of the lobster-moth (*Stauropus fagi*) is also a weird-looking creature, which, in its warning attitude, looks like a combination of a spider and an earwig.

The Caterpillar at Home. Some caterpillars escape a good many enemies by the sheltered nature of their homes, as, for example, wood-boring forms, such as those belonging to the goat-moth (*Cossus ligniperda*), which tunnel the trunks of willow and elm, and remain for four years in the larval stage. In other instances, protective cases or shields are constructed as a means of protection. The caterpillar of one species of clothes-moth (*Tinea pellionella*), for example, moves about in a tube constructed of fragments of cloth cemented together.

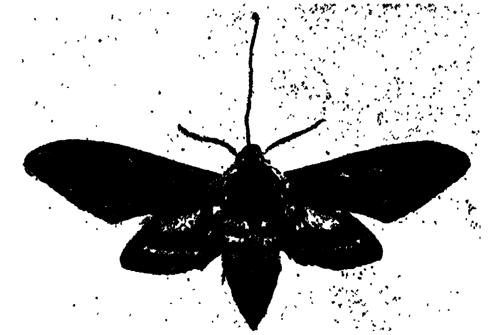


454. PROTECTIVE MIMICRY
a. Model *b.* Mimic
(Photo. by Prof. B. H. Bentley)

A similar habit has earned the name of "basket-worms" for the larvæ of certain small moths (*Psychidæ*), the homes of which are generally cylindrical cases made up of bits of wood or similar substances, and look very much like some of the tubes made by caddis-worms. One basket-worm constructs a spiral dwelling, looking exactly like a snail shell, and entirely made up of closely compacted silk. A somewhat different arrangement is found in the rather short caterpillar of a kind of moth (*Erastria scitula*) which creeps about with a dish-cover shaped shield upon its back [**457**], made out of the coverings of scale-insects which have fallen victims to its voracity, for this is an exception to the general rule that caterpillars are vegetarians. In some species—*e.g.*, the peacock butterfly (*Vanessa io*)—the larvæ are associated together in considerable numbers, at least when young, and spin a sort of protective web for mutual benefit.

456. LEAF-BUTTERFLY
(Photograph by Prof. B. H. Bentley)

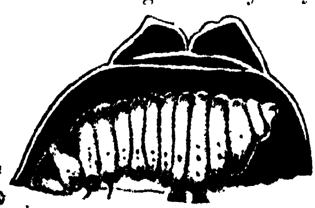
The Chrysalis. Sooner or later, a caterpillar becomes a hard-shelled, motionless chrysalis, and there are many ways in which this may be protected. Very often, before pupation begins, a thick cocoon of silk is spun, of which the most familiar instance is afforded by the larva ("silkworm") of the silk-moth (*Bombyx mori*). Sometimes cocoons are so tough that provision must be made for the escape of the perfect insect. In the emperor moth (*Saturnia carpini*) it is left open at one end, save for the presence of a ring of stiff, closely-set bristles, so arranged that they easily permit exit, but forbid the intrusion of an enemy. A still more curious method is adopted in the puss-moth, the cocoon of which is very thick and tough [**448**]. When the perfect insect escapes from the chrysalis, it excretes a corrosive fluid containing caustic



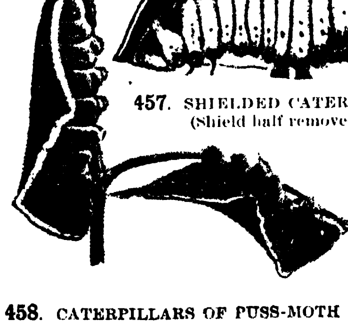
455. PRIVET HAWK-MOTH
(Photograph by Prof. B. H. Bentley)

potash, by which a part of the cocoon is dissolved. During this process the head of the insect is protected by a fragment of the chrysalis skin.

Sometimes protection is gained by the assumption of the chrysalis stage underground, in which case there may either be a cocoon or not. The privet hawk-moth [**445**] illustrates the latter state of things. The caterpillar of one of the British owlet-moths (*Brephos notha*) bores into a tree-trunk before pupating, first taking care to close the hole by spinning one or two silken screens to keep out foes. An exposed cocoon commonly resembles its surroundings, and is thus likely to escape notice. A good instance is afforded by the wood-eating caterpillar of the goat-moth, which at the end of its larval life bores its way to the surface and pupates in some fissure of the bark, constructing a cocoon which, though mainly of silk, is covered by chips of wood.



457. SHIELDED CATERPILLAR
(Shield half removed)



458. CATERPILLARS OF PUSS-MOTH

A great many chrysalides are neither hidden away from sight nor invested in cocoons, and may be found in all sorts of places, either hanging head downwards or disposed in the opposite way. In the former case, attachment is by means of a pad of hardened silk, and the tip of the tail is sometimes provided with a pair of hooks fixed into this. When the tail is below it is similarly fixed by a pad, while a girdle of silk often encircles the upper part of the body and holds it to the support. Colour is in all these cases a matter of great importance. Warning black and yellow tints are displayed in the case of the magpie moth (*Abraxas grossu-*

laricata)—which wears the same livery in all three stages of its existence—and in some other species, but the general rule is for exposed chrysalides to be protectively coloured.

Very remarkable is the case of some forms in which the chrysalis is of different colour, according to the prevailing hue of the surroundings. This is markedly so in the small tortoiseshell butterfly (*Vanessa urticæ*), light, dark, or even golden hues being assumed, according to circumstances.

The Adult Stage. Coming now to the adult, or imago stage of butterflies and moths, there is an enormous amount of variety as regards size, shape, and colour, of which but a faint idea can be given here. On the one hand, we have the great atlas-moth (*Attacus atlas*) with a 12-in. spread of wing, while some tropical butterflies (*Ornithoptera*) may attain to 7 in. or more; and, on the other hand, we have such insignificant little beings as the larch-moth (*Coleophora laricinella*), which can scarcely span three-eighths of an inch with fully expanded wings.

We have already had occasion to notice the mutual adaptation that exists between flowers and the members of the present order. The proboscis of a moth or butterfly is eminently adapted for sucking up the sweet nectar which so many blossoms afford, and its length in a particular species is proportionate to the depth at which the coveted treasure is hidden. Among our native species the hawk-moth is best endowed in this respect [**455**], and in some tropical forms it is even said to attain the length of 10 in. when extended. When not in use this organ is rolled up into a spiral under the head [**440**].

Colours of Butterflies. The colours of butterflies and moths in their adult condition are even more significant than those of caterpillars and chrysalides. Perhaps in the majority of cases they are of a protective nature, which accounts for the sober tints, specklings and mottlings which distinguish the bulk of our native moths. When most common butterflies settle and fold their wings over the back, only the underside of these is visible, and its tints are not of a conspicuous nature. If, as often happens, the two sexes are differently dressed, the female is more inconspicuous than her mate, an obvious advantage to the species. She may even be wingless, or practically so, as in the vapourer moth (*Orgyia antiqua*), and is discovered by her ardent admirers by the sense of smell, their large feathery antennæ indicating unusual endowment in this direction.

But colour, aided by shape, is capable not merely of bringing about a general harmonising with surroundings, but also a resemblance to specific objects on the lines noticed for stick-caterpillars. An exceedingly pretty example of this is afforded by our common little buff-tip moth (*Pygæra bucephala*). When this settles, the wings are wrapped round the body, and the insect strikingly resembles a little piece of broken stick, even the paler tint of the fractured end being accurately copied. The tropical leaf-butterflies (*Kallima*) go much further. They settle on twigs [**456**], fold up their wings, and then look precisely like withered leaves. Two little tails on the hind-wings come together to represent a stalk, mid-rib and branch-veins are perfectly simulated, and the apposition of two transparent spots near the tips of the fore-wings even bring about the semblance of a hole drilled by some larva. There are also discoloured patches closely resembling the fungi so commonly found on decaying leaves.

Patterns and Designs in Colour. Warning colouration is abundantly illustrated among adult butterflies and moths. The glaring black-and-yellow livery of the magpie-caterpillar is retained by the adult, while the striped yellow-and-black blazer of the cinnabar-caterpillar gives place to scarlet and dark brown. The pretty little six-spotted burnet-moth (*Zygæna filipendulæ*) is made conspicuous by contrast between scarlet, very dark green, and some black. In all these cases the effect is heightened by pattern as well as actual colour. Spots and bands are characteristic. A bold design in black upon a paler background is often very effectively employed [**454**]. It may also be noted that in warningly coloured species both sides of the wings are much alike, and that the flight is deliberate.

A number of species quite devoid of noxious properties and perfectly edible mimic more or less closely their warningly coloured neighbours, and in this way enjoy a certain amount of peace and quietness. A typical instance is figured in **454**. Remarkable cases have been described where the female only is a mimic, and is to be found in as many as three different garbs, simulating the same number of warningly coloured forms. Clear-wing moths (*Sesiidæ*) have come to resemble wasps and bees, and are thus undoubtedly in some measure protected. Their wings have lost most of the scales, so as to be transparent, and the body is banded with black and yellow or black and red, as the case may be

Colour and Courtship. The most beautiful and artistic combinations of tints on the wings of butterflies are generally explained as being examples of courtship colouration, a view which is rendered probable by the fact that they are often best seen in the male. A beautiful native example is afforded by the orange-tip butterfly (*Anthocharis cardamines*), which has received its name from the pretty marking of the fore-wings in the male; and in most of the elegant little blues (*Lycænidæ*) the female is brownish with a bluish tinge, while her mate is of the most glorious azure. It must also be added that some of the colours and patterns of butterflies and moths may perhaps be explained as recognition markings, by means of which members of the same species are spared mistakes in identification of their kind.

Continued

DAWN OF THE RENAISSANCE

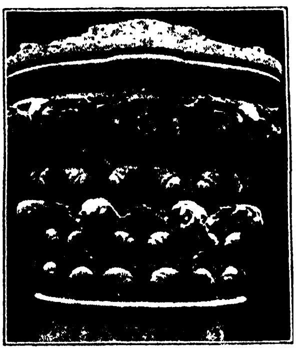
Gothic Art—continued. **A Period of Naturalism. Ivory Carving. Some Great Painters. The Dawn of the Art of "Free Expression"**

HISTORY OF ART
continued from page 3376

By P. G. KONODY

WE have exclusively dealt with the structural principles of Gothic architecture and the far-reaching changes brought about by the general adoption of the pointed arch. It is only natural that the sister arts of sculpture and painting, which were then completely in the service of, and subordinated to, architecture, should have had to undergo corresponding modifications. With the reduction of solid masonry to a minimum, the demand for extensive wall paintings had practically ceased to exist. Their place in the new order of things was taken by huge stained-glass windows, and the painters had to express themselves in small panel pictures for altar-pieces, which could no longer be monumental in character, but forced the artists from hierarchic dignity and lifelessness to the search for human emotions and movement. This signified the inauguration of a return from the traditional convention to the study of Nature.

Gothic Sculpture. In sculpture, even more than in painting, naturalism triumphed over formalism. Romanesque sculpture had been derived entirely from Roman and Byzantine sources. It was impressive at times and dignified, and well suited to the architecture by which it was set off. But the Gothic style of building, with its upward tendency and graceful slenderness, necessitated a different treatment of the human figure, which, in the hands of the mediæval sculptor, became more flexible, slender, elegant, and expressive—in short, more human. As in the preceding epoch, the representation of the nude remained beyond the pale of art, but, nevertheless, the form of the limbs was better understood, and the drapery treated in gently-flowing lines and ample folds. At the same time the features lost their stony impassiveness, in the place of which we find serenity and even emotional expression.

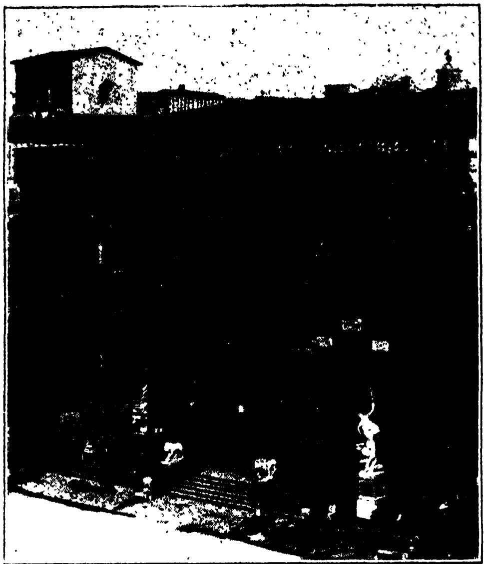


61. GOTHIC CAPITAL IN ROUEN CATHEDRAL

A Period of Naturalism. More marked even than in sculpture, properly speaking, is the naturalistic tendency in Gothic stone carving, where the forms of the local flora are repeated with astounding faithfulness, and with an appreciation of the beauty of Nature's handicraft that has never been equalled at any other period. Some of the Gothic cathedrals present in the stone carvings of the capitals, porches, and niches a perfect course of natural history—an encyclopædia of the knowledge of the time, comprising scriptural history, legend, contemporary life in all its phases, the sciences and trades and crafts, animal and plant forms, allegorical representations of the forces and phenomena of Nature, and many other themes. This applies with particular force to the cathedrals of France [61]; but even in Italy, where the alien Gothic style never became properly naturalised, we find a similar intention in the decorative adjuncts to architecture. Thus the relief panels of the Florence Campanile deal with the creation of Adam and Eve, "Jabal—the father of such as have cattle," "Jubal—the father of all who handle harps and organ," Tubal Cain, the metal-worker; Noah, the vine-grower; astronomy, arithmetic, geometry, grammar, logic, rhetoric, music, building, pottery, wool weaving, law, the three elements personified by a horseman, Dædalus, and a ship with its crew; ploughing, transport, painting and sculpture. This Campanile has not inaptly been called a "Gospel of Intelligent Labour."

60. SCULPTURE FROM THE CAMPANILE OF GIOTTO, FLORENCE

The Gothic craftsmen of France and Germany attained great skill in the polychromatic treatment of stone carving, and more particularly of figures and reliefs carved in wood, for altars and church decoration in general. That a period with a distinct leaning towards realism should not have neglected portraiture is only natural. The beginnings of Gothic portrait sculpture must be searched for in the cathedrals, among the tomb slabs showing the figure of the dead carved in low relief. Then came the recumbent figure modelled in the round, and finally the kneeling figure in the attitude of prayer, in all of which the sculptors endeavoured to reproduce as faithfully as possible the features of the dead.


Brogi

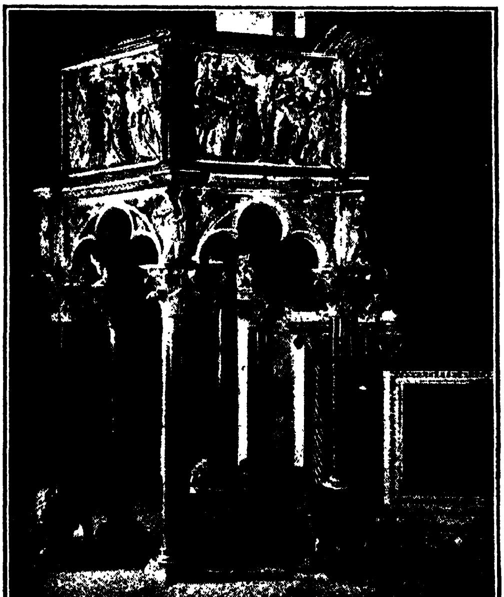
62. ORCAGNA'S LOGGIA DE' LANZI, FLORENCE

Ivory carving, too, was widely practised during the Gothic period, and no doubt exercised a great influence on the plastic art of that time. The shape of the tusk necessitated the adaptation of the pose of the figure to the curve. Perhaps the more flowing line and increased movement of Gothic sculpture, as compared to Romanesque, may to a certain extent be due to the artist's endeavour to fit his figures into a given shape, or indirectly to the accidental form of the elephant's tusk. It is at any rate undeniable that many of the statues carved in stone or wood during the fifteenth century follow the swinging line of the ivory's natural growth.

Italian Gothic Art. In Italy, painting and sculpture had never lost their independent existence as completely as in the North, where the Gothic architectural system exercised tyrannical sway over the sister arts. The smouldering fire that burnt under the cold Byzantine tradition broke forth in brilliant flame in the middle of the thirteenth century in the person of Niccola Pisano, the creator of the famous pulpit in Pisa [63], who, inspired by the antique, revived for a short time the noble grandeur of classic form. But Niccola was an isolated phenomenon, and his son, Giovanni, abandoning the direction indicated by his father, succumbed to the influence of the Northern Gothic, and gave his compositions dramatic intensity and emotional life in the place of antique impassiveness. His masterpiece is the pulpit of St. Andrea at Pistoja.

Whilst plastic art thus received a new impulse from Pisa, Florence and Siena were the centres where painting first broke the fetters of Byzantine formalism and achieved individual freedom. Cimabue, a thirteenth-century Florentine, has for centuries been held to be the father of modern painting and the teacher of Giotto. Modern research has, however, deprived him one by one of all the existing works that had been placed to his credit, and has made of him an almost legendary figure. It is now generally held that Cimabue was a mosaic worker trained by Byzantines in the accepted tradition—an excellent artist, no doubt, who perhaps infused a little life into the stiff manner of his precursors, but by no means the epoch-making reformer of Vasari's pretty tale. The famous Rucellai Madonna in Florence, and other panel pictures formerly attributed to Cimabue, are in all probability the works of Duccio of Siena and other painters of the Sienese school.

The "First Modern Painter." Whether Giotto was actually a pupil of Cimabue or no, one thing is certain, that his art has far more in common with that of the sculptor Giovanni Pisano than with that of his supposed master. Giotto (1266-1337) may be called the first modern painter. He was the first to paint objects and figures in a manner to make us realise without mental effort the plastic reality of his painted subject. Measured by the modern standard, his drawing is faulty, the figures clumsy and heavy, the perspective wrong; but his was the first step towards freedom of composition, dramatic life and movement, towards the realisation of an artistic ideal beyond the merely formal beauty of harmoniously arranged line and colour. To appreciate his work fully, one has to study his glorious frescoes in the Arena Chapel in Padua, at St. Croce in Florence, and at St. Francis in Assisi. Like most of the early Italian masters, Giotto was well versed in many arts. His combined achievement as architect and sculptor can be admired in the Florence Campanile [60].


Brogi

63. PULPIT, PISA, BY NICCOLA PISANO

In his painting, as in his sculpture, he, like all the leaders in art, drew his inspiration direct from Nature. And like all those who turn away from Nature to imitate consciously the work of a master, the followers of Giotto—the "Giottesques"—lost sight of the real significance of things, copied the weaknesses and the mere outer form of the admired models without grasping the spirit, and delayed the progress of painting by a full half century. Giotto the painter had logically transferred to another sphere, and developed the principles underlying the work of the sculptor Giovanni Pisano. It was a sculptor again, Andrea Pisano, who was Giotto's legitimate successor; and whilst painting was under a temporary eclipse, Andrea and his pupils infused vigorous life into the art of relief sculpture. With the seriousness and sincerity of Giotto, and with that master's disregard of conventional form, he combines an increased sense of pure beauty. His bronze gates of the Florence baptistery represent him at his best.

The greatest of the "Giottesques" is Andrea del Cione, called Orcagna, Andrea Pisano's pupil, and equally famed as painter, sculptor, goldsmith and architect. The Loggia de' Lanzi [62] in Florence is said to be built from his plans; the solemn, splendid fresco of the Last Judgment in S. Maria Novella, and the richly sculptured Gothic tabernacle at Or San Michele in Florence, are wrought by his hand, though the famous, naïvely realistic "Triumph of Death" fresco at the Campo Santo in Pisa, which was formerly attributed to his brush, is now held to be the work of the Sienese Lorenzetti [64].

What Cimabue was believed to have done for painting in Florence, Duccio di Buoninsegna certainly did for Siena. He, too, broke away from Byzantium, gave life to his figures, suggested the human form under the nobly-arranged drapery, and humanised the expression of the faces, though he did not go far in giving individual character and emotion to each figure. His successors, among whom Simone Martini, Taddeo Gaddi, and the Lorenzetti were the most prominent, continued in the same direction. The Sienese were ever more concerned with expressing the inner life of the soul than the physical life of the body. It was a natural consequence that they excelled more in the small panel picture than in the large fresco. The Sienese School did not have the vitality of the School of Florence, and fell into decay when the art of the rival city achieved its greatest triumphs.

A Great Florentine Painter. Fra Giovanni Angelico da Fiesole (1387-1455), a Dominican monk, is the last great Florentine painter of the Gothic period, and the first of the Early Renaissance. In his art, pure, spiritual, ardent, and sincere, he proves himself a follower of Giotto in the dramatic conception of the subjects and in the freedom of his grouping, whilst the soulful, emotional depth of his sentiment and the celestial beauty and purity of expression are derived from Sienese sources. He is the most lovable painter of all times, the painter of heavenly bliss, of pure Christianity, of angelic beauty. The spirituality and saintliness of his art is so striking, and has been laid so much stress on, that many critics have overlooked another and scarcely less important side of his character, his systematic study of the antique, of the human form and of Nature in general. He was the first painter who represented the Christ-child entirely naked, and drew the nude forms, not from imagination, but from the living model; the first Italian who painted an actual landscape from Nature; one of the first to study aerial perspective, to introduce actual portraiture into his frescoes, and classical forms

64. PART OF THE PAINTING OF THE TRIUMPH OF DEATH, PISA, BY LORENZETTI

65. A FRESCO BY FRA ANGELICO, IN THE MUSEUM OF ST. MARK, FLORENCE

into his architectural backgrounds. For all these reasons Fra Angelico must be accorded a position, and no mean position, among the painters of the Italian Renaissance. To appreciate Fra Angelico's position in the art of his time, it is necessary to study his wonderful frescoes in the cells of S. Marco in Florence and in the chapel of Nicholas V. in the Vatican [65].

The Renaissance. The great movement in art and letters, known as the Renaissance, had its beginning in Italy in the early part of the fifteenth century. In the Gothic period art had been almost entirely at the service of the Church. Fostered by the spread of humanism, which, under the rule of the Medici family in Florence, led to the establishment of a Platonic Academy, the dormant love of the Italians for the forms of classic art, which are so closely connected with paganism, was given a new powerful impetus. Scientists and men of letters, architects, painters and sculptors devoted themselves to the study of classic literature and antique art, the writings of Greek and Roman poets and philosophers were popularised, the fragments of antique sculpture unearthed, the ruins of classic buildings investigated, and the lessons derived from them applied to the creation of new monumental buildings. At the same time, and as a result of the "renaissance" or "re-birth" of classic knowledge, art became to a great extent secularised, and its patronage passed from the Church to the Courts of the Princes and to the wealthy citizens. In the North, the Reformation, coincides with the Renaissance, and even in Italy, where the Church enlisted the service of the masters that had arisen under the influence of the humanists, new fields were opened to the activity of architects, painters and sculptors. Mythology, classic literature and portraiture, entered into the range of subjects, and though some of the greatest churches and monastic buildings belong to this period, the great architects of the Renaissance found their chief employment in the building of palaces.

"An Art of Free Expression." Nothing could be more erroneous, however, than to think that the principles of Renaissance architecture were a mere repetition of the re-discovered classic forms. The style is based on the revival of the classic orders, but these are applied in an entirely new manner, suitable to the modern requirements. As Professor Banister Fletcher has tersely put it, "Architecture ceased to a certain extent to be subject to the considerations of use, becoming largely independent of constructive exigencies, and to a greater extent an art of free expression in which beauty of design was sought for. Speaking generally, there was an endeavour to reconcile the Gothic and the Roman method of construction—*i.e.*, the body and the dress were the same thing constructively, because the architects of the period, attracted by the mere external appearance of ancient Roman art, but perceiving that this form was merely an envelope, continued in the matter of construction to a large extent to follow the traditions of the Middle Ages, which did not separate the structure from the decoration."

Continued

ALGEBRAIC SURDS

Simple Surds. Surds of the Same Order. Compound Surds. Rationalisation. Square Root of a Binomial Surd. Equations Involving Surds

Group 21
MATHEMATICS
25

ALGEBRA
continued from page 3415

By HERBERT J. ALLPORT, M.A.

SURDS

119. In Article **143** of Arithmetic [page 1440] a *surd* was defined as a root of a number which cannot be determined exactly. Thus $\sqrt{7}$ and $\sqrt[3]{5}$ are surds. In Algebra, such expressions as $\sqrt[3]{x^2}$ and $\sqrt{y}$ are called surds, although if x and y have particular values, the resulting expression may not really be an arithmetical surd. For example, if $y = 25$, then $\sqrt{y}$ is not really a surd, since its value is $\sqrt{25}$, or 5.

120. Surds are really cases of fractional indices, and therefore are subject to the laws of combination established in Article **117**.

Thus, we know that

$$\sqrt[3]{a^2} = a^{\frac{2}{3}} \text{ [Art. 114]},$$

and that

$$\sqrt[12]{a} = a^{\frac{1}{12}}.$$

Hence,

$$\sqrt[3]{a^2} \times \sqrt[12]{a} = a^{\frac{2}{3}+\frac{1}{12}} \text{ [Art. 117]}$$
$$= a^{\frac{3}{4}} = \sqrt[4]{a^3}.$$

121. Surds are said to be of the same *order* when they have the same root index.

Thus $\sqrt{7}$ and $\sqrt{a+b}$ are surds of the *second* order, or *quadratic surds*.

$\sqrt[3]{x}$, $\sqrt[3]{x^2+y^2}$, are surds of the *third* order; and, generally, $\sqrt[n]{x}$ is a surd of the nth order.

122. Any rational quantity can be expressed as a surd. For example, to write 4 as a surd of the third order, we have

$$4 = \sqrt[3]{4^3}.$$

Again, a surd of any order can be converted into a surd of a different order. For instance, to transform $\sqrt[3]{5}$ into a surd of the 9th order,

$$\sqrt[3]{5} = 5^{\frac{1}{3}} = 5^{\frac{3}{9}} = \sqrt[9]{5^3}.$$

123. Any two surds can be transformed to surds of the same order. This order will be some common multiple of the given orders. For convenience, we generally choose the *lowest* common multiple.

Example **1**. Reduce $\sqrt[3]{4}$ and $\sqrt[5]{3}$ to surds of the same order.

The L.C.M. of 3 and 5 is 15. Hence,

$$\sqrt[3]{4} = 4^{\frac{1}{3}} = 4^{\frac{5}{15}} = \sqrt[15]{4^5},$$

and

$$\sqrt[5]{3} = 3^{\frac{1}{5}} = 3^{\frac{3}{15}} = \sqrt[15]{3^3};$$

so that the given surds are now expressed as surds of the 15th order.

We are thus able to compare the magnitudes of two or more surds.

Example **2**. Which is the greater $\sqrt[3]{17}$ or $\sqrt{7}$.

As in Example **1**, we have

$$\sqrt[3]{17} = \sqrt[6]{17^2} = \sqrt[6]{289},$$

and

$$\sqrt{7} = \sqrt[6]{7^3} = \sqrt[6]{343};$$

so that, since 343 is greater than 289, it is clear that $\sqrt{7}$ is greater than $\sqrt[3]{17}$.

124. Since

$$\sqrt[n]{ab} = (ab)^{\frac{1}{n}} = a^{\frac{1}{n}} \cdot b^{\frac{1}{n}} = \sqrt[n]{a} \cdot \sqrt[n]{b},$$

we see that the product of two surds can be simplified by reducing the surds to the same order.

Example **1**. Find the product of $\sqrt{27}$ and $\sqrt{48}$.

$\sqrt{27} \times \sqrt{48} = \sqrt{27 \times 48}$, since the given surds are both of the second order,

$= \sqrt{3^4 \times 2^4}$, by putting 27 and 48 into factors,

$= 3^2 \times 2^2 = 9 \times 4 = 36$ *Ans.*

Conversely, we can sometimes put a surd into factors, thus.

Example **2**. Express $\sqrt{147}$ in its simplest form.

$$\sqrt{147} = \sqrt{49 \times 3} = \sqrt{49} \times \sqrt{3} = 7\sqrt{3} \text{ \textit{Ans.}}$$

125. Surds are said to be *like*, when they can be reduced so as to have the same irrational factors.

$5\sqrt{20}$ and $2\sqrt{45}$ are *like* surds, for

$$5\sqrt{20} = 5 \times \sqrt{4} \times \sqrt{5} = 10\sqrt{5},$$

and

$$2\sqrt{45} = 2 \times \sqrt{9} \times \sqrt{5} = 6\sqrt{5}.$$

Clearly, the algebraical sum of like surds is obtained by collecting the coefficients, the result forming the coefficient of the sum, the irrational factor of the sum being the same as in the surds.

Example **1**. Simplify $2\sqrt{98} - \sqrt{18} + 5\sqrt{8}$.

$$2\sqrt{98} - \sqrt{18} + 5\sqrt{8} = 2\sqrt{49 \times 2} - \sqrt{9 \times 2} + 5\sqrt{4 \times 2}$$
$$= 14\sqrt{2} - 3\sqrt{2} + 10\sqrt{2}$$
$$= (14 - 3 + 10)\sqrt{2}$$
$$= 21\sqrt{2} \text{ \textit{Ans.}}$$

Example **2**. Simplify

$$2\sqrt{80} + \sqrt{3} - 4\sqrt{12} - \sqrt{20}.$$

Given expression

$$= 2\sqrt{16 \times 5} + \sqrt{3} - 4\sqrt{4 \times 3} - \sqrt{4 \times 5}$$
$$= 8\sqrt{5} + \sqrt{3} - 8\sqrt{3} - 2\sqrt{5}$$
$$= (8 - 2)\sqrt{5} - (8 - 1)\sqrt{3}$$
$$= 6\sqrt{5} - 7\sqrt{3} \text{ \textit{Ans.}}$$

Note that unlike surds cannot be added or subtracted, so that $6\sqrt{5} - 7\sqrt{3}$ admits of no further simplification.

126. A *compound surd* is an expression involving two, or more, simple surds.

Compound surds are multiplied together in the same way as other compound algebraical expressions. [See Article **27**, page 2148.]

Example. Multiply

$$3\sqrt{5}+2\sqrt{3} \text{ by } 2\sqrt{5}-5\sqrt{3}.$$

We have to multiply every term of the one expression by each term of the other. Hence, the product consists of

$$(3\sqrt{5}\times 2\sqrt{5})+(2\sqrt{3}\times 2\sqrt{5})-(3\sqrt{5}\times 5\sqrt{3}) - (2\sqrt{3}\times 5\sqrt{3});$$

or

$$30+4\sqrt{15}-15\sqrt{15}-30,$$

which, on collecting terms, gives $-11\sqrt{15}$. The work can be arranged as in Article **27**, thus,

$$\begin{array}{l} 3\sqrt{5}+\ 2\sqrt{3} \\ 2\sqrt{5}-\ 5\sqrt{3} \\ \hline 30\ +\ 4\sqrt{15} \\ \quad\ -15\sqrt{15}-30 \\ \hline 30\ -11\sqrt{15}-30=-11\sqrt{15}\ \underline{\textit{Ans.}} \end{array}$$

127. If we multiply together the sum and the difference of two quadratic surds, we get a rational expression for the product.

For, by Article **34**, page 2150,

$$(\sqrt{x}+\sqrt{y})(\sqrt{x}-\sqrt{y})=(\sqrt{x})^2-(\sqrt{y})^2=x-y.$$

Two binomial quadratic surds, which differ only in sign, are said to be *conjugate* to one another. Hence, a binomial quadratic surd is *rationalised* by multiplying by the conjugate surd.

128. When a fraction has surds in the denominator, the denominator can be rationalised, and the numerical value of the fraction is then found more easily.

Example **1**. Rationalise the denominator of $\frac{14}{\sqrt{7}}$.

We have only to multiply numerator and denominator by $\sqrt{7}$. Thus

$$\frac{14}{\sqrt{7}}=\frac{14\times\sqrt{7}}{\sqrt{7}\times\sqrt{7}}=\frac{14\sqrt{7}}{7}=2\sqrt{7}\ \underline{\textit{Ans.}}$$

Example **2**. Rationalise the denominator of

$$\frac{2\sqrt{3}+3\sqrt{2}}{5+2\sqrt{6}}.$$

The denominator becomes rational if we multiply by the conjugate surd $5-2\sqrt{6}$. We therefore multiply both numerator and denominator by $5-2\sqrt{6}$. Hence,

$$\begin{aligned}\frac{2\sqrt{3}+3\sqrt{2}}{5+2\sqrt{6}} &= \frac{(2\sqrt{3}+3\sqrt{2})(5-2\sqrt{6})}{(5+2\sqrt{6})(5-2\sqrt{6})} \\ &= \frac{10\sqrt{3}+15\sqrt{2}-4\sqrt{18}-6\sqrt{12}}{25-24} \\ &= 10\sqrt{3}+15\sqrt{2}-12\sqrt{2}-12\sqrt{3} \\ &= 3\sqrt{2}-2\sqrt{3}\ \underline{\textit{Ans.}}\end{aligned}$$

Example 3. Rationalise the denominator of

$$\frac{1}{1+\sqrt{2}+\sqrt{3}}.$$

We have

$$\begin{aligned}\frac{1}{1+\sqrt{2}+\sqrt{3}} &= \frac{1+\sqrt{2}-\sqrt{3}}{(1+\sqrt{2}+\sqrt{3})(1+\sqrt{2}-\sqrt{3})} \\ &= \frac{1+\sqrt{2}-\sqrt{3}}{(1+\sqrt{2})^2-(\sqrt{3})^2} \\ &= \frac{1+\sqrt{2}-\sqrt{3}}{3+2\sqrt{2}-3} \\ &= \frac{1+\sqrt{2}-\sqrt{3}}{2\sqrt{2}} \\ &= \frac{\sqrt{2}\,(1+\sqrt{2}-\sqrt{3})}{2\times 2} \\ &= \frac{2+\sqrt{2}-\sqrt{6}}{4}\ \underline{\textit{Ans.}}\end{aligned}$$

129. We come now to an important proposition in surds.

If $a+\sqrt{b}=x+\sqrt{y}$, where a and x are rational, and $\sqrt{b}$ and $\sqrt{y}$ are irrational, then will $a=x$ and $b=y$. For, since

$$a+\sqrt{b}=x+\sqrt{y}.$$

Therefore,

$$a-x+\sqrt{b}=\sqrt{y}.$$

Squaring both sides we have

$$(a-x)^2+2(a-x)\sqrt{b}+b=y;$$

so that

$$2(a-x)\sqrt{b}=y-b-(a-x)^2.$$

Hence we have an irrational quantity equal to a rational one, *unless the coefficient of $\sqrt{b}$ is zero*, in which case the left-hand side of the equation becomes zero. But a rational and an irrational quantity cannot be equal. Therefore the coefficient of $\sqrt{b}$ must be zero, *i.e.*, $a-x=0$, so that $a=x$. It follows, from the given relation, that $\sqrt{b}=\sqrt{y}$, or $b=y$.

NOTE. Since $a=x$ and $\sqrt{b}=\sqrt{y}$, it follows that

$$a-\sqrt{b}=x-\sqrt{y}.$$

It must be remembered that the result just established is only true when $\sqrt{b}$ and $\sqrt{y}$ are really irrational, *i.e.*, b and y cannot have values which are perfect squares.

For example, it is true that

$$4+\sqrt{9}=3+\sqrt{16};$$

but this does not tell us that $4=3$ and $9=16$.

130 If

$$\sqrt{a}+\sqrt{b}=\sqrt{x}+\sqrt{y},$$

then will

$$\sqrt{a}-\sqrt{b}=\sqrt{x}-\sqrt{y}.$$

For, squaring the given relation, we have

$$a+\sqrt{b}=x+y+2\sqrt{xy};$$

and, by Article **129**, we may equate the rational terms, obtaining

$$a=x+y, \quad . \quad . \quad . \quad . \quad (1)$$

and we may also equate the irrational terms, obtaining

$$\sqrt{b}=2\sqrt{xy}. \quad . \quad . \quad . \quad . \quad (2)$$

Subtracting (2) from (1) we get

$$\begin{aligned}a-\sqrt{b} &= x+y-2\sqrt{xy} \\ &= (\sqrt{x}-\sqrt{y})^2.\end{aligned}$$

Therefore,

$$\sqrt{a-\sqrt{b}}=\sqrt{x}-\sqrt{y}.$$

131. The square root of a binomial which consists of a rational term and a quadratic surd can sometimes be found.

Example. Find the square root of $9 + 4\sqrt{5}$. Let

$$\sqrt{9+4\sqrt{5}} = \sqrt{x} + \sqrt{y}. \quad . \quad . \quad (1)$$

Then, by Article 130,

$$\sqrt{9-4\sqrt{5}} = \sqrt{x} - \sqrt{y}. \quad . \quad . \quad (2)$$

Multiply (1) by (2). Then

$$x - y = \sqrt{9^2 - (4\sqrt{5})^2} = \sqrt{81-80} = 1. \quad . \quad (3)$$

Squaring (1) and equating the rational parts, we obtain

$$x + y = 9. \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Solving (3) and (4) we find

$$x = 5,\ y = 4.$$

Hence,

$$\sqrt{9+4\sqrt{5}} = \sqrt{5} + \sqrt{4} = \sqrt{5} + 2 \ \underline{\textit{Ans.}}$$

132. We can, however, generally write down the square root by inspection. The square of $\sqrt{x} + \sqrt{y}$ is

$$x + y + 2\sqrt{xy}.$$

Therefore,

$$\sqrt{x + y + 2\sqrt{xy}} = \sqrt{x} + \sqrt{y}.$$

Hence, the square root of $A + 2\sqrt{B}$, *where the coefficient of* $\sqrt{B}$ *is* 2, is $\sqrt{x} + \sqrt{y}$, x and y being such that

$$x + y = A \text{ and } xy = B.$$

In the example of the last Article, to find the square root of $9 + 4\sqrt{5}$ we must first make the coefficient of $\sqrt{5}$ equal to 2. Thus

$$9 + 4\sqrt{5} = 9 + 2\sqrt{2^2 \times 5} = 9 + 2\sqrt{20}.$$

To obtain the square root we have now only to find two numbers whose sum is 9 and whose product is 20. These are easily seen to be 4 and 5. Hence

$$\sqrt{9+4\sqrt{5}} = \sqrt{4} + \sqrt{5} = 2 + \sqrt{5} \ \underline{\textit{Ans.}}$$

133. Equations Involving Surds. We shall now solve one or two equations in which the unknown quantity appears under the square root sign.

Example **1**. Solve $\sqrt{x} + \sqrt{5x+1} = 2$.

We bring a single radical term to one side of the equation, and put everything else on the other side. Thus

$$2 - \sqrt{x} = \sqrt{5x+1}.$$

By squaring, we get rid of the radical on the right-hand side

$$4 + x - 4\sqrt{x} = 5x + 1.$$

We now collect terms, and again put a single radical term on one side and everything else on the other, and square. Thus,

$$4\sqrt{x} = 3 - 4x.$$

Therefore,

$$16x = 9 - 24x + 16x^2,$$
$$16x^2 - 40x + 9 = 0,$$
$$(4x-9)(4x-1) = 0.$$

Therefore,

$$x = \tfrac{9}{4} \text{ or } \tfrac{1}{4} \ \underline{\textit{Ans.}}$$

Example **2**. Solve

$$\sqrt{16-7x-x^2} = x^2 + 7x - \frac{1}{4}.$$

Here it should be noticed that the coefficients of x^2 and x under the radical sign, *viz.*, -1 and -7, are in the same ratio to one another as the coefficients of x^2 and x in the rest of the equation. Whenever this is the case, the equation is transformed into a form readily solved if we put the radical equal to y.

Thus, let

$$\sqrt{16-7x-x^2} = y.$$

Then,

$$16 - 7x - x^2 = y^2. \quad . \quad . \quad . \quad (1)$$

Therefore,

$$x^2 + 7x = 16 - y^2.$$

Therefore the given equation becomes

$$y = 16 - y^2 - \frac{1}{4};$$

$$4y^2 + 4y - 63 = 0.$$

Whence,

$$y = \frac{7}{2} \text{ or } -\frac{9}{2}.$$

Substituting these values of y in (1) we obtain two quadratic equations, *viz.*,

$$16 - 7x - x^2 = \frac{49}{4},$$

and

$$16 - 7x - x^2 = \frac{81}{4}.$$

Solving these, we obtain four values of x,

$$x = \frac{1}{2},\ -\frac{15}{2},\ \text{or}\ \frac{-7 \pm 4\sqrt{2}}{2} \ \underline{\textit{Ans.}}$$

EXAMPLES 33

Simplify

1. $\sqrt{45} - \sqrt{20}$.
2. $3\sqrt{48} + 5\sqrt{27} - 2\sqrt{12}$.
3. $4\sqrt[3]{24} - \sqrt[3]{81}$.
4. $\sqrt{13} \times \sqrt{52}$.
5. $\sqrt{32} \div \sqrt{72}$.
6. $\sqrt{27} \times \sqrt[3]{9}$.
7. Multiply $3\sqrt{2} - \sqrt{5}$ by $2\sqrt{2} + 3\sqrt{5}$.

Find the square roots of

8. $11 + 4\sqrt{6}$.
9. $52 - 7\sqrt{12}$.
10. Simplify
$$\frac{1+\sqrt{2}+\sqrt{3}}{1+\sqrt{2}-\sqrt{3}} - \frac{1-\sqrt{2}-\sqrt{3}}{1+\sqrt{2}-\sqrt{3}}.$$

Solve the following equations

11. $1 + 2x\sqrt{1-x^2} = 9x^2$.
12. $\sqrt{5x+1} - \sqrt{x} = 1$.
13. $\sqrt{58-13x} - \sqrt{13x+7} = 3$.

Answers to Algebra

Examples 31

1. $a - b + 2c$.
2. $a + bx - 2cx^2$.
3. $\frac{x^2}{6} + \frac{x}{3} - 1$.
4. $2x^3 - x + 3$.
5. $x^2 + xy - 2y^2$.
6. $2x^2 - \frac{2}{x} + \frac{4}{x^4}$.

Examples 32

1. 9.
2. $\frac{1}{3}$.
3. $\frac{1}{16}$.
4. 125.
5. $\frac{x}{y^4}$.
6. $x^{\frac{5}{12}}$.
7. 1.
8. y^{15}.
9. $2x^{\frac{5}{2}} + 2x^2y^{\frac{1}{3}} - 5x^{\frac{3}{2}}y^{\frac{2}{3}} - 2xy + 4x^{\frac{1}{2}}y^{\frac{4}{3}} - y^{\frac{5}{3}}$.
10. $x^{\frac{2}{3}} - x^{\frac{1}{3}} + 1$.
11. $2x^2 - 3x^{-1} + 4x^{-4}$.
12. $2x^2 - 1 - 2x^{-2}$.
13. $x - 2x^{\frac{1}{2}} - 1 + 2x^{-\frac{1}{2}} + x^{-1}$.

Continued

HARP
continued from
page 3400

HARP PRACTICE

Pedal Changes for Major Scales. The Melodic and Harmonic Minor. Chromatic Scales. Fingering. Modulation. Key "Colour"

By ALGERNON ROSE

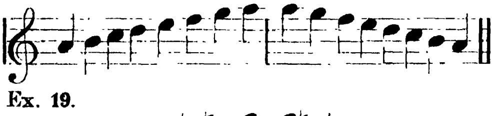
COMPARED with the pianist, the harpist may be said to learn his scales backwards in regard to their signature. Doubtless, many harp teachers have explained verbally how the pedal changes are made in the simplest way into all the different keys, but we have not come across any such information in print. The SELF-EDUCATOR may therefore be particularly helpful at this juncture.

The fact that the natural scale of the double-action harp contains seven flats, B, E, A, D, G, C, F, need not perplex. These flats correspond to the number of levers in the pedestal of the instrument. Write them down in their proper order on a piece of music-paper. To put the entire compass of the harp into a key which has six instead of seven flats—namely, G♭—what has the student already done? He has knocked off the last flat, F, in the signature of the harp's natural scale. In other words, he has put down the F pedal one notch. Likewise, to play in the key which has five instead of six flats (D♭ major), he deletes the next flat, C, by slipping down the C pedal one notch. To play in A♭, which has four instead of five flats, he gets rid of the next accidental, G. How? By lowering the G pedal one notch. To transpose the instrument into E♭ major, which has three instead of four flats, he expunges the D♭ in the signature by depressing the D pedal one notch. To modulate all the strings into B♭ major, which has two instead of three flats in the signature, he takes away the redundant A♭ by lowering the A♭ pedal one notch. To get into the key of F major, which has one instead of two flats, he dismisses the E♭ by putting down the E♭ pedal one notch. Finally, to get rid of the B♭, he puts down the B♭ pedal one notch. All the pedals are now down.

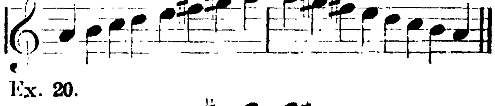
It is as if a company of soldiers were kneeling instead of standing to shoot. Every string throughout the instrument has been raised half a tone, just as the sights of the soldiers' rifles have been raised to get a longer aim. So the key of the harp is now C♮, represented by the white notes on the piano. The next problem is to get into the sharp keys. What has the harpist to do? The key with one sharp is G major, in which the accidental is F. To add this, press down the F♭ pedal to the second notch. This raises all the blue strings a second semitone. The key with two sharps is D major, of which the second accidental is C. Press down, therefore, the C♭ pedal to its second notch. This raises all the red strings another half-tone. That key which has three sharps is A major. G♯ has to be added. Therefore, lower the G♭ pedal to its second notch. E major rejoices in four sharps, the

Ex. 16. **MODULATION FROM C MINOR TO G MINOR** [G Minor]

Ex. 17.

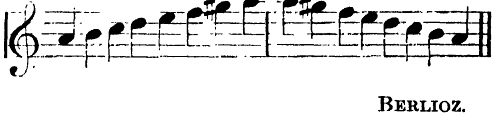


Ex. 18.



Ex. 19.

Ex. 20.



Ex. 21. BERLIOZ.

Ex. 22. CROSS FIRE

fourth being D. Consequently, to get it, down goes the D♭ pedal to its bottom notch. B major is the key with five sharps, the fifth being A. So lower the A♭ pedal to its second notch. The key with six sharps is F♯ major, the sixth being E♯. In the same way, depress the E♭ pedal as far as it will go. Lastly, the key with seven sharps is C♯ major, the seventh accidental being B. Therefore, lower the B♭ pedal in the same way.

All the pedals are now down to the second notches. It is as if the company of riflemen are in a prone position, with all their sights put up as far as they will go so as to enable shooting at the maximum range. In the same way that, if all the pedals are put up, there are seven flats in the signature of the piece to be played, so now, when all the pedals are down in the second notch, the harp is transposed into a key with seven sharps.

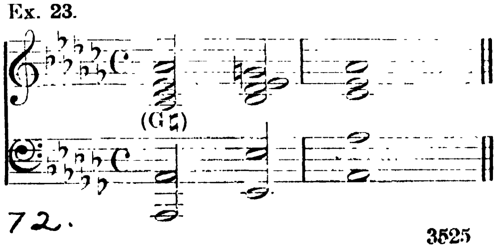
Minor Scales. Hitherto we have confined our attention to the major scales. But the minor form, which, as its name implies, occupies a subordinate place to the major, has undergone many changes. Originally, it was the tone-system in common use, having been derived from one of the ancient Greek forms and introduced thence into the music of the Early Christian Church. In ancient harp music there are plenty of melodies built up on the old Greek scale. Being the most ancient of stringed instruments, the harp was tuned in a minor rather than, as now, the major mode. Consequently it is the system of tuning rather than the nature of the instrument itself which makes it so difficult to-day to render chromatic passages on the double-action harp. Even if the instrument, however, were tuned differently, it would not enable it to meet the requirements of certain modern composers. The only result would be so to confuse the player as to necessitate his relearning the instrument. The old Greek minor scale is shown in Ex. **17**. (The previous Example, Ex. **16**, is referred to later.)

But this system gave no leading note or sound a semitone below the tonic, essential in the modern form of the scale. If the G only was sharpened, that meant that the interval from F♮ to G♯ exceeded a whole tone. It was long considered admissible to augment the tone in such a way. So the F was raised to F♯, and the first alteration of the Greek system sounded as Ex. **18**.

Yet, although the effect was delightful as the sounds rose from the lowest to the highest notes, they were too much like the major scale when they went downhill. Consequently, the sharps to G and F in descending were omitted. That simple alteration gave the Western world what is known as the "Melodic Minor Scale." In the method of transition coming down the change contrasts pleasantly with the well-defined steps going up. The æsthetic reason for the charm which the ear finds in the melodic minor are discussed at length in Helmholtz's "Tonempfindungen" and Pole's "Philosophy of Tone." In the melodic minor the sound-ladder is as written in Ex. **19**.

The Harmonic Minor. Considering how many modes, or series of different scales, were required to satisfy the ears of the Greeks, as those of the Indians and Chinese to-day, it is remarkable that Europeans for a long period contented themselves with only two forms, the major and the melodic minor. It took centuries before theoreticians would allow that an augmented tone was permissible. They agreed that a leading note going up to the tonic was wanted. This necessitated, to their minds, the F♯ as well as the G♯. Practical musicians, nevertheless, began to associate F♮ with G♯. Eventually, therefore, practice overruled theory. Not only was the ancient F♮ restored, but the descending was made to conform with the ascending scale. The result was our modern sequence, known as the harmonic minor. [Ex. **20**.]

Ex. 23.



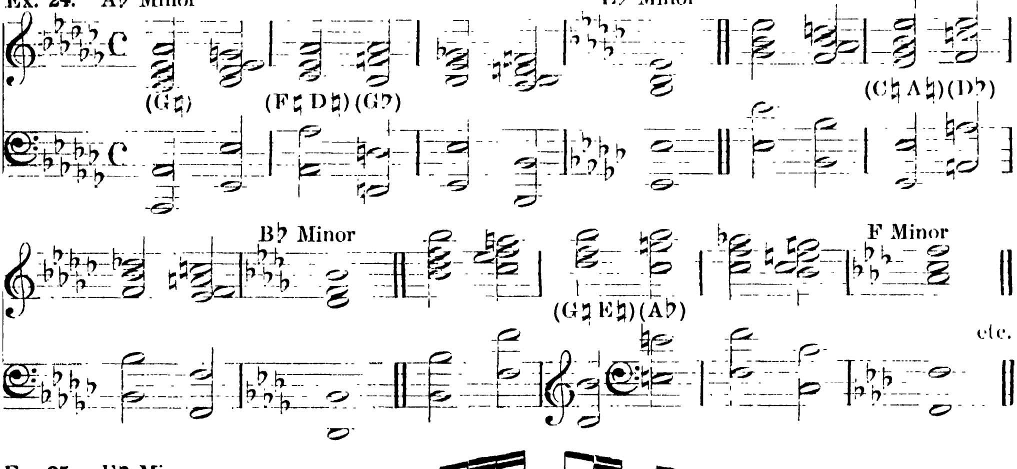
172.

The problem of putting new wine into old bottles, we know, is difficult to solve. The modern musical wine, with its abundant discords, is somewhat at variance with the anatomy of the ancient harp. Ingenious as is the double-action mechanism of the modern harp, composers are too often unmindful that it is essentially a diatonic instrument. It will have been perceived, by the pedal changes already given, that transition from major keys to those nearly related to them is simple. But the student will long since have become aware that, if the F♭ pedal is depressed, he cannot raise the tone of one F without affecting similarly the sounds of all the other F's, or any other note chosen, throughout the scale. To make an instrument, therefore, which is essentially anti-chromatic dodge about in detached semitones renders exceedingly difficult, if not impossible, the execution of rapid passages where the accidentals ascending are unlike those used when descending.

Wagner, and later eminent composers, have not infrequently recorded passages for the harp which are most embarrassing. Professor Prout instances, in the final scene of the "Walküre," a phrase consisting of four groups of semiquavers in each bar, requiring, in almost every little batch, a change in the harp of two and sometimes three pedals. Clearly such sequences of notes are opposed to the character of the instrument. Yet an orchestral player is expected to make bricks without straw, and the sooner the ambitious student realises that fact the better will it be for him ultimately.

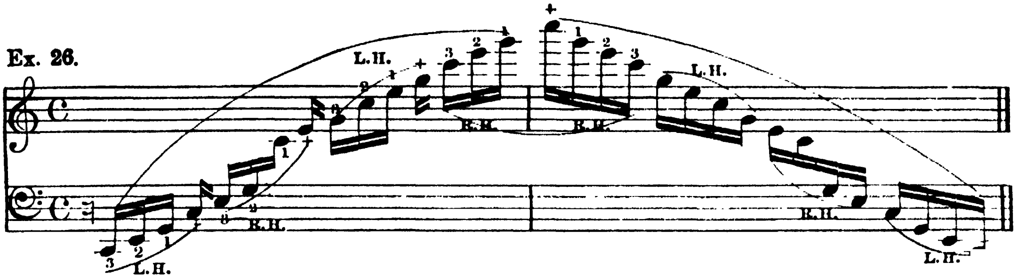
The Chromatic Harp. To meet the demand of certain modern composers who score for the harp as if it were a piano, M. Gustave Lyon, of Paris, introduced in 1903 a harp without pedals, but with the strings arranged so that those representing the white notes of a keyboard are on one side of the player and the black notes on the other. Although this arrangement met with favour at the Brussels Conservatoire, it has not been taken up by harpists generally. As pointed out by Mr. George Morley, it deprives the instrument of its strong individuality without imparting to it the capabilities of the piano. Therefore, the student can scarcely hope to have access to such an extra instrument on the orchestra. If he is ambitious, there is nothing for him but to get through, as best he can, the enharmonic briars and brambles with which the modern composer takes a weird delight in pricking the harpist's fingers.

Ex. 24. A♭ Minor

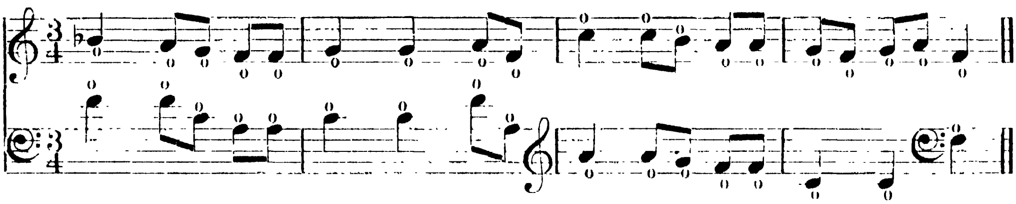


Ex. 25. E♭ Minor
In Tenths

Ex. 26.



Ex. 27.



Chromatic Difficulties. As a preliminary illustration of the difficulties to be encountered, let the student practise slowly with one hand, going up and down the scale in semitones. Endeavour to play each note in strict time A child can do this on the piano without trouble, but to accomplish the same thing on the harp means putting into action in rapid succession, for the first octave only, some five pedals, quitting them as promptly, and repeating the same gymnastics in the octave above. [Ex. 21.]

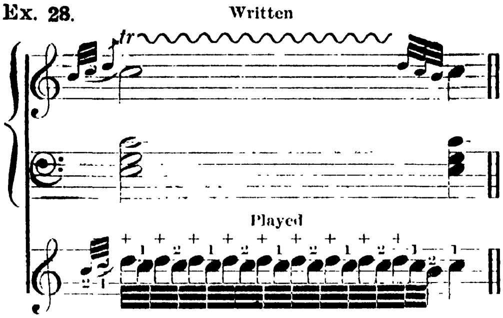
It is customary with composers who are considerate to warn the player to prepare in advance for a pedal change by inserting in the music "G♯" "F" "E" or whatever note is coming that is foreign to the key signature. When minor keys are executed at even moderate speed it will, of course, be evident that the requisite pedals must be changed almost instantaneously.

Two Harps. But in one sense the composer, instead of being denounced for writing detestable passages, ought to be thanked by harpists. The peculiar difficulties he has set down have frequently led a careful conductor to engage two performers instead of one at a concert, and, consequently, pay double fees. Two harps also, by interweaving parts and playing what are known as "cross fires," get a clearer and better effect in certain passages. [Ex. 22.]

Now put up all the pedals so that the harp is in its natural scale, or signature, of seven flats. Take the minor scales systematically, as was done in the case of the major. A minor third below C♭ is A♭. This, therefore, is called the "relative" minor of the major scale already played. But the semitones in the *minor* scale, instead of, as in the major coming between the third and fourth and seventh and eighth notes in ascending or descending, now occur in the harmonic minor, it must be remembered, between the second and third, fifth and sixth, and seventh and eighth, and the same in descending. In the melodic minor, however, they come between the second and third and seventh and eighth notes going up, and the sixth and fifth and third and second coming down. The latest word in harp-playing at the time of writing has been said by M. Raphael Martenot. But even he, in his "Méthode de Harpe: Théorique et Practique," confines the attention of the advanced student, when it comes to minor scales, to the harmonic form. Before beginning the A♭ harmonic minor, play with all the pedals up the tonic chord. Next try the dominant chord given in the example, consisting of the notes E♭, B♭, D♭, E♭, and G♮. To get the G♮, lower the third pedal on the right to the first notch. [Ex. 23].

The Fingering. No matter how many or how few sharps or flats a minor scale contains, the fingering is uniform in all keys. When the harp is played in octaves, it is the same for both hands. Herein the student has a great advantage over the pianist. Prepare the left hand for the A♭ (third ledger line, bass clef, below staff), and the right hand for the A♭ (first space, bass clef) an octave above. Care should always be taken in preparing the fingers not to touch the strings prematurely, so as to prevent any unnecessary vibration. The student also should make it a rule to familiarise himself thoroughly with one difficulty and overcome it before proceeding to the next. Strike each A♭ with the third finger; the B♭ with the second finger; the C♭ with the first; and the D♭ with the thumb; always making preparation in advance. For the E♭ above use the third finger; for the F♭, the second; the G♮, the first; and A♭, the thumb. For the B♭ strike with the second; the C♭, the first; the D♭, the thumb; and the E♭, the third. For the F♭ use the second; G♮, the first; A♭, the thumb; and B♭, the second. For the C♭ above, the first; the D♭, the thumb; E♭, the third; and F♭, the second. For the G♮, the first finger; A♭, the thumb; B♭, the second; and C♭, the first. For the D♭, the thumb; E♭, the third; F♭, the second; and G♮, the first. For the top A♭, completing a four-octave scale, use the thumb.

Ex. 28.



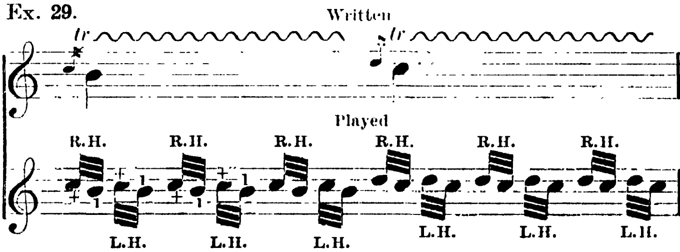
In descending, reverse the order of the fingers, so that the digits strike the same notes in like sequence as in ascending. Now, there is nothing bewildering in all this. It is really simple. The student should write out the notes and fingering for himself. He will then observe that, in going up, the third, second, first and thumb are used twice. Then comes a change to second, first, and thumb, followed by first, second, first, and thumb; and that order is continued up to the top A, the same rule applying when coming down.

Modulation. The gymnastics, therefore, do not occur in the fingering, but in the pedalling. Always accustom the eye to read at least a bar ahead, because the pedals have to be changed and released while the scale is being played. As uniformity in the rate of progression by both hands is indispensable in scale practice, the effect will be unsatisfactory if pauses are made to enable the feet to do their work. A "scale" implies a ladder, as the word is derived from the Latin, *scala*. The art in scale playing is therefore to run up and down the imaginary ladder in such a way as to make the gradation in the series of tones or half-tones so regular that the steps may not be noticed. The sounds must flow evenly, thereby concealing the art which is necessary for their production. But the musician's ear is dissatisfied if one minor scale, say, in seven flats, is ended abruptly, and the next, in six flats, begins immediately, without some appropriate chord intervening. What is wanted is a tonal bridge, so that the two keys may be linked by appropriate modulation. To transpose the harp from a major scale in seven flats into one in six, we knock off, as already explained, the last flat in the signature—namely, F—by depressing the second pedal on the right one notch. But before doing this, after completing the scale of A♭ minor, confirm it by its dominant chord, which contains G♮. For this the right pedal has to be put down.

To get the first inversion of the new dominant, before finishing with a perfect cadence leading into E♭ minor, put down to the first notch the second (F) pedal and the third left (D), reinserting the G♭ by releasing the third right pedal. After practising the E♭ minor scale, modulate in the same way (by depressing the C and A pedals one notch, and releasing the D pedal) into the key of B♭ minor, with five flats. The obliteration of one flat in each succeeding signature is effected by depression of the pedal in question one notch, as explained in the major scales. Thus we go from B♭ minor, with five flats, to F minor, with 4, C minor, with 3 [Ex. **16**], G minor, with two, and D minor, with one, until we arrive at A minor, which is without accidentals in the signature. Then we add one sharp for E minor, which has F♯ in its signature, because it is the relative of G major. So the F♭ pedal is slipped down to its second notch. In the same way add a second sharp for B minor, a third for F♯ minor, a fourth for C♯ minor, and so get round the circle. For the modulations we give an example from Mr. Oberthur's "Harfen-Schule." By raising the alternate scales a tone at a time, and similarly altering the pedal indications, the student should have no difficulty in transposing on paper the other minor scales with their modulations. [Ex. **24**.]

The Melodic Minor. Although the harmonic minor form of ascending and descending the scale may suffice usually, it behoves the student, whilst accepting general principles, to prepare himself for the many violations he will find of them in certain orchestral parts. Having become familiar with the harmonic minor scales in octaves, the amateur, however, who is confining his attention to solo work can devote his leisure to arpeggio exercises in keeping with the character of his instrument. But the student who has a hope of eventually securing an orchestral engagement at a provincial festival cannot afford to overlook the tendency that some modern writers have to make their music jump about in semitones remotely related to the signature of the key in which the work begins. Plenty of fresh difficulties to overcome will be found if the melodic minor scales are now tackled through all keys, not only in octaves, but in tenths, sixths, and thirds. The difficulties of pedal arrangement necessitate movements of the feet which cannot be made rapidly enough to correspond with their relative strings so as to enable the scales to be executed in quick time. Moreover, such pedal adjustments cause a great deal of noise. Yet, as an exercise for familiarising the student with chromatic entanglements, persistent attempts to execute slowly the scales in intervals which cannot be performed quickly will give him, often by means of borrowed notes, such as using a

Ex. 29.



G♯ for an A♭, etc., an insight into the most expeditious way of rendering, instinctively, unusual notations as artistically as possible. [Ex. 25.]

Key "Colour." Sound, like colour, is dependent upon the rapidity or slowness of vibration, the undulations which produce low notes being less rapid than those which give us the high ones. In like manner, the colours of the rainbow recorded by the spectrum almost double themselves, when passing from red to violet, in velocity of pulsation. When a piece, therefore, is played throughout in C♭, and is afterwards transposed to a higher key, the complexion, or colour, of the music changes.

But it is as easy to play in one key as in another on the harp. The student should take advantage of this fact. He can spare himself thereby the monotony of constantly repeating one exercise in the same key as he would have to do if he practised any other instrument. He should now go back, repeat, and, if ingenious, add to the exercises already tabulated, and increase his interest in them by trying them in all the keys. If, for example, he practises the scale of C major by depressing all the pedals to the first notch, striking the notes very slowly, he can then transpose the scale into the key of G, slightly increasing the speed. Afterwards, he can continue it in D major. Next go to A major, E, and so on, until he has modulated through all the keys and obtained infinite variety whilst exercising his fingers all the while in the same manner. He will soon find himself able to play in any key his fancy dictates. But he should remember this fact. The tone of the harp is richest in its natural key, and least sonorous when the pedals are depressed to the second notch. Why? Because the strings are then shortened, and it stands to reason that a long string possesses more resonance than one which has had an inch cut off it. Therefore, although on the piano the key of F♯ major, with six sharps, and G♭ major, with six flats, sound alike, this is not the case on the harp.

HOMOPHONES

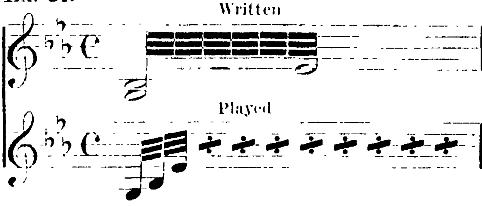
* Alternate notes played on G♯ string

To play in the former key, the harpist has six of his pedals down to the second notch, so that most of the strings are considerably shortened. On the other hand, if he plays in G♭ major, he has only one pedal, the F♭, down to the first notch. This accounts for the reason why, in an orchestral score, the harp part sometimes appears to be written in a wrong key. Should the harpist come across a solo in F♯ major, he will do better justice to himself and his instrument by playing it in the enharmonic key. But for practising purposes, if he succeeds in getting a rich tone out of the sharp key, he will add to his confidence when playing in the natural scale. Now take groups of four notes, first with the left hand and then with the right, as here indicated, and exercise the fingers with them through all the keys. Endeavour to strike each note with equal force. Be careful to keep strict time. [Ex. 26.]

Harmonic Sounds. On the harp, harmonic effects are particularly beautiful, although only one such sound is produced from each string instead of several, as can be obtained from each string of a violin. To produce the harmonic, press the middle red string very lightly at exactly half its length. Do this with the first joint of the first right finger, curved down while the thumb strikes the note. Immediately this sounds, remove the finger from the string. Do not bend the second, third, and little fingers too much. Hold them gracefully. Now, with the left hand, try the octave C below. Press the middle of the string gently with the fleshy part of the palm, not the ball of the thumb. Sound the note as before with the thumb. Harmonics on the harp are finest in the bass and middle register of the instrument, and are seldom written above D, fourth line, treble clef. In the music, they are denoted by an O over the notes, or sometimes by "s.h.," meaning *sons harmoniques*. Try a simple melody in this manner. Practise first with one hand, then the other. Afterwards play with both together. [Ex. 27.]

Homophones. From the explanation given of the pedals, it will be understood that in harp music there are neither double sharps nor double flats. When such occur in modern compositions, the harpist has to play the enharmonic equivalent. On the piano there is only one key for D♭ and C♯, for E♭ and D♯, for F♭ and E♮, for F♮ and E♯, for G♭ and F♯, for A♭ and G♯, for B♭ and A♯, for C♭ and B♮, and for C♮ and B♯. But on the harp, by means of the pedals, each of the foregoing notes

Ex. 31. TREMOLO



can be represented by separate strings next to each other. These are called "homophones," or "synonyms." [Ex. 30]. By means of such doubled notes, extraordinary effects can be obtained of a delightful character impossible on any other instrument, after the harpist has put down, say, the pedals for D♯, E♭, F♯, G♭, A, B♮, and C♭. This leads us to "sliding" effects.

The Glissando. On the piano it is possible to accomplish this in a complete scale only, along the white keys, or in C major. By means of the pedals, the harpist has the advantage of the pianist. Delightful glissandos on the harp can be made in every key, at any rate of speed, and with any degree of strength desired, from the softest whisper to the loudest sound the strings can give. Further, by means of the pedals, glorious effects can be obtained on the double-action harp through the use of "homophones," to which we have alluded.

To produce this effect, slide the thumb and third finger, or the thumb, first, second, and third fingers along any arpeggio passage after the pedals have been suitably arranged. Pass the thumb down the whole succession of the strings. Prepare the first, second, and third fingers to execute the last notes just before the thumb reaches the bottom of the passage. For the ascending glissando, use the first finger. After sounding the top note, take the hand instantly off the strings. Directions for this manner of playing are indicated either by the word *glissando* or *strucciolamento*, meaning, "to slide." After practising this effect with one finger of each hand, try two fingers, because the gliding can be done effectively in thirds, sixths, octaves, tenths, as well as seconds and fourths.

Damped Sounds. The French for "damped" or muted sounds is *sons étouffés*. To get this effect, place the whole of the hand flat against the strings with the fingers shut and their tips touching the strings. Sound the string by the thumb, and force the ball of the thumb against the string to damp the sound. Keep the thumb rigidly upright. Use the tips of the fingers by pressing them against the strings, to give the thumb the necessary leverage. For sounding the next note, the thumb is got ready by a slight movement. Notes to be played in this manner are marked in the music thus ⊕. For marches, chords struck in this way are very appropriate. To play them, keep the elbow low. Round the fingers less than usual. The palm must be close to the strings, so as to stop the sounds at once. As the right wrist is supported by the soundboard, the damping with the right hand is done by the fingers.

To accomplish the shake the student must practise patiently and continually. The shake is produced by sounding one note and the next higher to it quickly, and repeating the operation as long as is necessary. Take care to move the fingers only. Keep the wrist flexible, and avoid any motion of the arm. Although only two notes are sounded, the shake is done best by using three fingers. Strike the upper note with the thumb. Sound the other note with the first and second finger alternately. [Ex. 28.]

Chain Shakes. It is well to practise the shake all up and down the scale. Use both hands alternately. Sound the notes at first very slowly. Always practise the shake in strict time. After exercising the fingers deliberately, double the speed. Go back to the slow tempo. Try again, as rapidly as possible. In other words, shake slowly for four bars, and then do the next four bars quickly. To trill powerfully and firmly, the thumb and the elbow must always be held high [Ex. 29]. A delightful tremolo effect is obtained by doing the shake on *homophones* or strings lying adjacent which give the same sound after the pedals have been adjusted to bring them into unison. If the tremolo passage, or the shake, is a long one, use the thumb and three fingers instead of two. Played very softly on the harp, the tremolo, or shake, has a distinctive charm. It is then marked *bis bigliamento*, which means whispering. [Ex. 30].

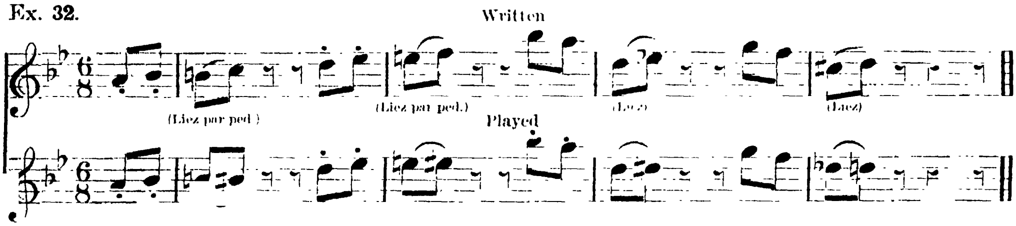
Tremoloed Arpeggios. This glorification of the ordinary arpeggio was introduced by the harp virtuoso, Parish Alvars. It requires considerable practice. Briefly, it is the rapid repetition of three or four notes, as shown in Ex. 31.

The guitar sound effect is indicated in harp music by the words *sons d'ongles*, or nail-sounds. These are created by striking the strings near the wrest-pins with considerable force, using the nails. Employ the tips of the fingers if the nails are not strong enough.

Lute Sounds. The words "near the soundboard" usually indicate the lute effect. It is supposed to resemble the tone of a wire-strung lute when struck by a plectrum. In this case press down the soundboard slightly with the fingers of the left hand, after each note has been struck as before near the pegs with the right hand. The pressure of the left fingers on the soundboard must be at the opposite end of the string actually struck. So as to give resistance to the tips of the fingers, use the thumb as a lever on the body of the instrument. This manipulation gives a portamento effect to the vibration, so that the sound of the string seems to be carried on to the next one.

Unique Effects. Amongst peculiar achievements indulged in by good harpists is that of altering the pitch of a sound by pressure of a pedal. Thus, play B♭. Immediately press down the B♭ pedal one notch. The vibration of all the B♭ strings pulsating in sympathy with the one struck will be raised half a tone to B♮. The sound, although the string is not again struck, glides up spontaneously a semitone with an æolian effect. This ingenious device is often used when two notes, one half a tone above the other, are connected by a slur. In music, the indication is *liez par la pedale*, or linked by the pedal. [Ex. 32.]

Ex. 32.



Harp concluded

Continued from page 3456

LEATHER BELTING

Different Modes of Transmitting Power. Belts versus Gearing. Tensile Strength. Belt Velocities. Power Transmitted

By W. S. MURPHY

Machine Driving Belts. Driving power from steam, gas, and water has to be transmitted to the machinery by means of shafting, with tooth and pinion wheels, by ropes, or by belts on pulleys. In some factories we find a combination of all three methods. The main drive may be transmitted from the engines by ropes on to the main shafting, tooth and pinion wheels taking the power along the ceilings of the machine-rooms on shaftings, from which belts take the power to the machines. Every workman has, or ought to have, a good opinion of the products of his trade. If you ask a millwright what is the best sort of drive, he will say that it is the tooth and pinion, of course, and give very strong reasons for his opinion ; if you ask a rope-maker the same question, he will prove to you, beyond all cavil, that the rope drive is unequalled, for heavy work especially ; and the leather belt maker has an even stronger assurance of the superiority of leather belts over all other power transmitters. It may be trade conceit, but we hold strongly to the idea that the belt drive is superior to all others for general purposes. Rope drives are difficult to regulate, the ropes being apt to develop different rates of speed, and produce an oscillating motion very trying to machinery ; the leather belt, being a unity, runs at one speed. Tooth and pinion wheels are liable to break without a moment's warning, a sudden jar smashing the teeth and bringing the machinery to a standstill while a new wheel is being got and put in place ; leather belts, on the other hand, give long warning, and in case of a break, a repair sufficient to carry through the work of the day is only a matter of a few moments.

Engineering Skill Useful. As he is the coadjutor of the engineer and machinery user, the belt-maker should possess more than a smattering of mechanical science. In the course of his work he will be called upon to solve many problems in mechanics. A leather belt maker who acquires a reputation for ability to help the engineer or the factory manager over difficulties is sure of success ; without that reputation and ability, he might never get a footing on the market. Moreover, the belt-maker is frequently offered tasks involving a high degree of engineering skill. To the uninitiated it seems impossible to transmit power round a corner with belts ; but it can be done, as our illustrations [23 and 24] show. It is in extensions of works that most of these problems come into existence. For some reason, the added building cannot be built in line with the old factory ; the new wings must be set at obtuse angles ; the main shaft of a new department needs to be set at right angles with the engine—for these eccentricities, and many others, the belt-maker has to be prepared.

At the very least a knowledge of mechanics is a defensive weapon without which the maker of belts may often be unjustly put down. The belts are frequently blamed for the faults of the machinery. Many instances of this could be given. A common cause of dispute between the belt-maker and the belt-user is the heating of bearings that stiffen the drive and bring about a disastrous break. When the cause is hurriedly sought, the bearing has cooled down, and because no other thing seems guilty the belt is blamed.

Use of Belts. The earliest and most obvious use of the leather driving belt was as a substitute for cord in power transmission over short distances. We can trace the steps by which the belt entered industry in the cotton manufacturing process. First there was the spinning wheel, the spindle of which was driven by a cord from the wheel ; next the improved hand loom, with leather thongs on the picking handle ; then the spinning machines, with shafting driven by water-power, and the belts connecting the pulleys on the shafting with the spinning frame. For a long time the belt drive was only used for small work—the driving of lathes, planers, looms, and all machine tools ; but the main drive was entrusted to the millwright. To the cautious, solid-working engineers of the early nineteenth century, the belt seemed a risky vehicle for high powers. What they would say now, if they saw a belt carrying 500 h.-p., it is impossible to guess ; but the fact would certainly surprise them. Makers of power transmitters have contended for the main drive as the prize to be won. Both engineers and leather manufacturers in this country seemed for a long time to consider leather belt out of the running for that high function. Between the engine and the driving machinery a space of as much as 150 ft. sometimes intervenes ; to piece the available lengths of leather hide together into such a length seemed, before it was successfully undertaken, a task insurmountable. The breadth, too, for carrying high powers was a problem. Ropes could be multiplied to need, tooth and pinion wheels could be made any size, woven belts might be made any breadth ; but the breadth of the hide alone was accepted as the limit of the breadth of a belt.

An American Example. Here we come upon one of the indirect benefits civilisation has derived from colonisation of wild and distant lands. So long as he had a

millwright or a rope-maker handy, the engine builder might never have given leather a chance of helping him ; but away out in the backwoods of America the case was wholly different. The hardy lumberer had water-power, timber, and oxhides in plenty ; but the millwright was far away, and freight of iron and steel is costly. But the pioneers of our race are handy men, to whom practical difficulties are merely a stimulus to invention. They made water-wheels and driving shafts of wood, and driving-belts out of the raw hides of oxen. When the bullocks were skinned, the hides were nailed upon wooden frames, and there dried and cured with the hair on. Cut into strips, the hides were softened by friction and grease, and laced together into the lengths and breadths required with raw-hide thongs. When population came along, and the settlement grew into a town, machinery also came, and the raw-hide belts rose to higher usefulness, their lightness, strength, and handiness giving the belts preference over all other transmitters. The belt-makers in the Motherland were not long in profiting by the example of our kinsmen beyond the seas, and began to undertake the whole of the power transmission, from engine to machine. Within recent years the trade has grown to large dimensions, and driving-belts are the familiar friends of all engineers. Larger and larger belts are being demanded, and, of course, a corresponding improvement in strength and lightness required. Belts 6 ft. in breadth and of great length are constantly in use at the present day, and belt-makers will cheerfully guarantee efficiency in belts 12 ft. broad.

Values of Belts. The qualities required in a driving-belt are strength, durability, and conveying power, with a minimum of stretch. On these points ample data have been supplied by the trade. In the various tables compiled we have found considerable discrepancy ; but the following have been drawn from reliable sources and practical experiment :

TENSILE STRENGTH OF LEATHER BELTS PER SQUARE INCH.		
Tannage.	Pressure at Breaking-point.	Per Cent. of Stretch.
	lb.	
Best British Oak-tanned	5,746	24
Best Foreign Oak-tanned	4,974	25·4
Common British Oak-tanned	4,243	25
Common Foreign Oak-tanned	2,708	—
Finest Chrome-tanned . .	10,050	32
Alumned and Stuffed . .	11,900	38·3
Alumned Rawhide . .	13,100	31·4

23. TRANSMITTING POWER
(Shaft is at right angl to machine)

One square inch of belting is equal to a belt 4 in. broad, ¼ in. thick. These tests are purely experimental, and bad conditions will altogether throw them out ; but a wise belt-user is sure to allow a considerable margin of strength.

Belt Velocities. The ability of belts to transmit power may be increased or diminished by several conditions. It is well known that wooden pulleys have a greater adhesion than metal ones, and lie more kindly to the belt. Observing this, some engineers offer leather-covered or rubber-covered pulleys to manufacturers desiring the best kind of drive. Wooden pulleys, or pulleys covered with leather or rubber, almost double the draught of the belt ; but the bare metal pulley wears longest and gives the most constant drive. Our calculations, therefore, are based on the use of metal pulleys. What might be called velocity problems take three forms, proceeding from two known factors to an unknown. First, and most important : at what speed will a belt, running at a certain velocity on a given diameter of pulley, drive a shaft ? Secondly : what is the diameter of pulley required to develop a certain belt velocity, with a shaft running at a given speed ? Thirdly : what is the belt velocity developed by a shaft running at a given speed, with a pulley of a certain diameter ? The three factors are mutually related and coefficient, change in the one altering the other two. The table itself, shown on next page, best illustrates the principle.

Transmitting Power. We have left the most important set of questions to the last. Every user of power is deeply concerned about how much horse-power he can get out of his engines and gearing. The question the belt-maker has to answer more frequently than any other is : What is the transmitting power of your drive ? This is the crucial point, and really involves all others. Horse-power 1-in. width leather belt will transmit :

SINGLE BELT.		DOUBLE BELT.	
Diameter of Pulley.	Belt Speed per Minute.	Diameter of Pulley.	Belt Speed per Minute.
Ft.	Ft.	Ft.	Ft.
1½	2,400	1½	1,333
2	1,600	2	1,000
2½	1,240	2½	1,875
3	1,066	3	730
3½	950	3½	625
4	800	4	500
5½	680	5	400
6	533	6	335
7	457	7	286
8	400	8	250
9	355	9	222
10	250	10	200

TABLE OF BELT VELOCITIES.								
Diameter of Drum, Ft.	2	2½	3	3½	4	4½	5½	—
Revs. of Shaft per min.								
100	628	785	942	1,099	1,256	1,413	1,727	ft. per min.
110	690	863	1,036	1,208	1,381	1,554	1,899	,, ,,
120	753	942	1,130	1,318	1,507	1,695	2,072	,, ,,
130	816	1,020	1,224	1,428	1,632	1,836	2,245	,, ,,
140	879	1,099	1,318	1,538	1,758	1,978	2,417	,, ,,
150	942	1,177	1,413	1,648	1,884	2,119	2,590	,, ,,
160	1,004	1,256	1,507	1,758	2,009	2,260	2,763	,, ,,
170	1,067	1,334	1,601	1,868	2,135	2,402	2,935	,, ,,
180	1,130	1,413	1,695	1,978	2,260	2,543	3,108	,, ,,
190	1,193	1,491	1,789	2,088	2,386	2,684	3,281	,, ,,
200	1,256	1,570	1,884	2,198	2,512	2,826	3,454	,, ,,

Slipping Belts. The practical details a leather belt maker has to consider are very numerous, and we can only touch on a few of the more important. When the belt slips, it is a temptation to adopt flanged pulleys; but this may only add to the mischief. The pulley is most likely off the plumb, and the belt, bearing up against the flange, is cut and frayed to pieces in no time.

To many the side of the belt which should lie next the pulley seems a matter of indifference, and some prefer the grain side because it presents a rougher surface. Here are two errors. Hardness is the last quality to be desired in a belt surface. The natural bend of all leather is towards the flesh side. Nature is emphatic on this point. The skin is a wrap round the body of the animal, and curves to the flesh it covers. Given fair play, the flesh side of the belt will hug the pulley and carry away every ounce of power from the driver and put it on to the driven pulley.

Belt to Pulley. The relations of belts to pulleys call for attention. The pulley should always be wider than the belt, and allow for the play of the drive. Narrow pulleys cut and score belts. The diameter of the pulley should be proportioned to the thickness of the belt. For heavy drives a thick belt is needed, and a machine user wants to get the highest shaft speed possible from his drive. He therefore is apt to work with small pulleys. But to bend a belt ⅞ in. thick round a drum 4 in. in diameter is suicidal. The bend produces creases, the creases wear, and the belt cracks. A gentle curve produces no appreciable strain on the leather, but a severe bend undoubtedly does, and takes from the tensile strength of the belt.

Compound Drive. Perhaps the most remarkable discovery made in regard to belting during the past forty years was the principle of compounding introduced by John Tullis. Seeing a locomotive engine with coupled wheels working with a heavy load on one pair of rails, the inventor thought that a pair of belts working on one pulley ought to carry something like double the power. He tried the idea by experiment, and found the theory correct. This simple expedient has saved much trouble and expense. If you want to transmit, say, a third more power, the common recourse would be larger or more pulleys and wider belts; but all you have to do is to put a belt on the top of the old one already working. Each belt takes its own drive from the engine to the shafts, and increases the driving power by 100 per cent. Compounding has given a mobility to belt-driving very wonderful to the inexperienced. On a single driving pulley you can put six driving belts, and let each driving belt drive a different shaft, with practically the same result as if you had erected six driving pulleys.

24. TRANSMITTING POWER
(Power at right angles to shaft)

Successful Compounding. Many instances are given by the inventor of success in the use of compound belt-driving; but we can only give two instances which illustrate the service of the device in overcoming a difficulty. Some years ago, extensions were being made in a London flour mill, demanding from 80 to 100 per cent. more power. The engine was quite capable of doing this, but the 14-in. belt was good for no more than it was driving. The first idea was to put in wider pulleys; but, as this involved much expense, both driver and driven being confined in a small space close to a main wall, the compound drive was resorted to. A 17-in. double orange-tan belt was put on next the pulley, and the old 14-in. double was put on top of it. This gave 100 per cent. more power at once, and the belts worked satisfactorily. A firm of linoleum manufacturers in Antwerp were also taken out of a difficulty. They were driving with a pulley of small diameter at high speed, and the double belt in use at first was unable to lift the load. Two single orange-tan belts, each 22 in. wide, were put on, and the whole difficulty was overcome.

Continued

Group 5
CHEMISTRY
25
Continued from page 3487

LACTIC AND SOME TOXIC ACIDS

The Acid of Milk and its Properties. The Amides. Prussic and other Acids and their Antidotes. Cyanogen

By Dr. C. W. SALEEBY

FURTHER on in the series of hydroxy acids we come to an extremely important body known as *lactic acid.* It is none other than hydroxy-propionic acid. Propionic acid has already been named and its formula given. Plainly, the hydroxy acid derived from it must have the formula CH_3-CHOH-COOH. This differs from the formula of propionic acid only in the middle term, which contains a hydroxyl instead of a hydrogen atom. Lactic acid is so called because of its production in milk, and a good deal has already been said of it, apropos of butyric acid and its production. Thus, the easiest fashion in which to prepare lactic acid is simply by lactic fermentation of sugar. When milk turns sour the cause is the production of lactic acid from the lactose of the milk under the influence of the lactic acid bacteria, first discovered by Pasteur. The characteristic sugar of milk, known as *lactose*, has the formula $C_{12}H_{22}O_{11}$. Add to this one molecule of water, and we see how the whole may split up into four molecules of lactic acid $C_3H_6O_3$. The process is really much more complicated than this statement, which will suffice, however, for our present purpose. In 1877, Lord Lister discovered what he called the *bacillus lactis*, which may or may not have been identical with that previously found by Pasteur. To-day we know a very large number of different bacteria that can cause this fermentation; indeed, more than a hundred different bacteria are known to do so. 172.

Lactic acid is of great interest for three distinct reasons—in the first place, chemically; in the second place, historically; and in the third place, practically. We must proceed, then, to consider it from these three points of view, though the very interesting history of the subject can be discussed only incidentally.

The Pure Chemistry of Lactic Acid. Hitherto we have spoken as if there were only one lactic acid, but as a matter of fact, there are more than one. In the first place we must note, merely as a matter of theoretical importance, that there is a second lactic acid which differs from the first in the internal arrangement of its atoms. Its constitutional formula differs from that of ordinary lactic acid, already given, since the hydroxyl group is in a different place. It runs thus: CH_2OH-CH_2-COOH. From the purely chemical point of view we may say, then, that there are two hydroxy-propionic acids, and we may distinguish them by the Greek letters *alpha* and *beta*.

But if we confine ourselves to ordinary lactic acid, we find that it also is of more kinds than one. In the first place, there is the acid which is obtained from milk by a process so important that we must afterwards describe it carefully. This acid is optically inactive—that is to say, it has no action upon the plane of a ray of polarised light when this is passed through a solution of it. But we have already seen that there is at least one optically inactive organic acid which, on investigation, proves to be inactive merely because it consists of suitable proportions of two acids, one *lævo-rotatory* or left-handed, and the other *dextro-rotatory* or right-handed. The same is true of lactic acid. If we take muscular tissue and treat it suitably, we obtain lactic acid from it, and this, since it is derived from flesh, is usually known as *sarco-lactic acid* (Greek *sarcos*, flesh). The name implies, by the way, that it comes both from milk and from flesh, which is absurd, but still it is convenient. Now sarcolactic acid differs from the more familiar lactic acid of milk in that it consists almost entirely of the right-handed acid. The two acids are of equal, though opposite, optic activity, and the inactive acid derived from milk therefore consists of the two acids in equal proportions.

Asymmetrical Carbon Atoms. Already some brief mention has been made of the question of symmetry in organic compounds—that is, symmetry of molecular constitution. We may now proceed to give the rigorous chemical definition of what is known as an asymmetrical carbon atom. It is one, each of the four hands of which is holding on to a different atom or group of atoms. This is the case in lactic acid, as we shall readily see if we write out the formula in the graphic form:

$$\begin{array}{c} CH_3 \\ | \\ HO-C-COOH \\ | \\ H \end{array}$$

Now the above formula is undoubtedly correct, but it is not the only possible formula. Suppose we held it up to a mirror and read it in the mirror, it would be the same and yet not the same. Your two hands are the same, and yet they are not the same. You would recognise this if you were suddenly provided with a left hand at the end of your right arm instead of your right hand. Similarly, in the case of many organic compounds, the molecular structure of two bodies may differ only as one's right hand differs from one's left. Your two hands are both human, and at birth, at any rate, were both identical in every respect save one; it is just that one respect in which right and left-handed lactic acids, for instance, differ from one another, and in that alone. We have purposely used the analogy of human hands because it seems a happy one,

and because the association of ideas cannot fail to recall it to the reader's mind whenever he is asked to explain, at a moment's notice, the difference between two such closely similar bodies. But, of course, we must not be confused by the use of the terms right and left-handed in the names of the acids. They are so-called not by analogy with hands, but because they turn the plane of a ray of polarised light to the right and left respectively. A little criticism can show, by the way, that the terms right and left can really have no meaning in relation to rotation, and it is a curious and significant fact that language provides us with no better substitutes for them than *clockwise*—that is, in the direction of the hands of a clock—and *contra-clockwise*.

The philosophic reader will see that, in discussing a matter apparently so prosaic as the difference between two kinds of acid found in sour milk, we are on the verge of considerations which raise the whole question of a conception no less stupendous in its significance than our fundamental conceptions of space and spatial relations.

Molecules and Light. If the reader be one of those who ponder over things after he has read them, yet another consideration will occur to him. When we were discussing the refraction and the reflection of light in the course on Physics, it was pointed out that our statement of the dogmatic laws of these phenomena must not lead anyone to suppose that we understand the actual relations of ethereal waves to ponderable matter. Is it not evident, however, that we are beginning to accumulate facts that will help us when we realise that, of two molecules, which differ from one another only as a right hand differs from the left, one will act upon a plane of etheral vibrations so as to turn it clockwise, and the other so as to turn it contra-clockwise? Why and how, we cannot yet say, but we must hold fast to the extremely important generalisation that *polarised light can be rotated only by bodies whose molecules possess an asymmetrical carbon atom.* So much for the pure chemistry of lactic acid.

Sour Milk. It has been proved beyond dispute that the souring of milk, or its lactic acid fermentation, depends necessarily upon the presence of living organisms. It does not occur spontaneously. If the organisms be excluded, milk may be drawn and kept for months without undergoing any change that can be detected. Pasteur first distinguished the lactic ferment from the alcoholic ferment. He found that when milk turned sour, there was usually a grey deposit consisting of bacteria. "Pasteur then introduced a trace of this deposit into a solution of sugar to which he had added a decoction of yeast and some chalk, and in this artificially-prepared liquid he thus obtained lactic acid fermentation. From this fermenting fluid he again transferred a slight trace to a similar solution of sugar, and so on, invariably obtaining the lactic fermentation and invariably finding the same corpuscles in the deposit." ["Bacteriology of Milk," page 155.]

We shall proceed to quote freely from the standard, if not indeed the only, notable work that has yet been written upon the bacteriology and bacteriological chemistry of milk and its products. "The lactic organisms produce appreciable amounts of lactic acids only at somewhat elevated temperatures. If the amount of acid rises much above 2 per cent., the growth of the lactic acid bacteria is inhibited." In general, the lactic acid bacteria do not form spores, and can therefore be killed readily by heat. Some are anaerobic, growing best in the absence of free oxygen. They sour milk best in deep vessels, and produce a right-handed lactic acid. Others produce various gases in the course of the fermentation—the production of which gives their character to certain kinds of cheese. The arrest of the process of fermentation by its own products may be noted, as it is similar to what we have already seen in the case of alcoholic fermentation, and would appear indeed to be a general principle in fermentative processes. Milk turns sour most readily "at between 35° C. and 42° C., and when 2 per cent. of lactic acid is reached, the process of further production ceases. If the milk be then neutralised with carbonate of lime, the process of fermentation will recommence until the acidity again stands at 2 per cent."

Milk and Hot Weather. Everyone knows that during the hot months of the year infants die like flies in all our large cities. One of the chief causes of this is the decomposition of the milk on which they are fed, and the reason why the hot months are so fatal, and why a cool summer saves many thousands of lives, is that the temperature we have indicated is the best temperature for the fermentation of milk, which proceeds rapidly in proportion as that temperature is approached. Part of the modern treatment of milk is to cool it to a point little above freezing point within a few seconds after it is first drawn. Really, no milk should be sold which has not been subjected to this process, unless it is to be drunk immediately after being drawn.

This is not the place in which to discuss the origin of the lactic acid bacteria. It has been conclusively proved that they are never a normal and original constituent of the milk, but are invariably "a secondary contamination of the milk from some external source."

Evil Results. The reader must not imagine, however, that the lactic acid fermentation of milk is to be looked upon as entirely evil. It has two very different aspects. The lactose of milk is one of the most valuable of its food constituents, and if it be decomposed before the milk is drunk the food value is lost. This is a serious matter in the case of an infant, but not the most serious. For the lactic acid is itself injurious to the delicate internal structure of an infant, as also is the growth of the bacteria which produce it. Well worthy of note is the significant fact that the one carbohydrate supplied by Nature for food purposes—namely, the lactose of milk—is far more resistent to fermentation than ordinary sugars. This is one reason why sugar of milk is much preferable to cane sugar or to glucose in the artificial feeding of infants.

Good Results. But, on the other hand, lactic acid fermentation of milk is of very considerable economic value *in the right place.* In this complex world there are few things that are wholly good or wholly evil, and probably none that are good or evil in themselves. These adjectives can be applied only to the appropriateness or unappropriateness, the fitness or unfitness of things—in short, not to themselves, but to their relations.

Thus lactic acid fermentation causes what is known as the ripening of cream, and this is a process of very great value, as everyone ought to know who has ever tasted butter. At the present day economic bacteriology—which is to be discussed in a subsequent course—is making an exhaustive study of dairy bacteriology, and very notably of the conditions of lactic acid fermentation, which is all-important in the making not merely of butter, but still more of cheese. The lactic acid bacteria constitute about 95 per cent. of all organisms present during the ripening of cheese. We have already hinted that the appearance of Gruyère cheese is due to the activity of organisms which, in the course of the production of lactic acid, also produce gas.

The Views of Professor Metchnikoff. Quite recently the world-famous scientist, Professor Metchnikoff, of the Pasteur Institute, has made studies which suggest a new importance for lactic acid. This subject must briefly be referred to, and for further details the reader may be referred to Metchnikoff's "Nature of Man" (English translation, Heinemann, 1903), and also to the second of Professor Metchnikoff's Harben Lectures, delivered at King's College on May 28th, 1906. In the chapter entitled, "The Scientific Study of Old Age," in the book referred to, Professor Metchnikoff points out that civilised man suffers considerably from the effects of fermentation within the alimentary canal. He goes on to show that the lactic acid bacteria contained in milk, and especially in sour milk, are inimical to the development of the ordinary bacteria of putrefaction, since these latter multiply only in an alkaline medium. He says "the lactic acid microbes produce large quantities of acid, and so hinder the multiplication of the organisms of putrefaction. Putrefaction takes place rapidly, in spite of the presence of the lactic acid microbes, if there be added soda to . . . meat or milk." "It is plain, then, that the slow intoxications that weaken the resistance of the higher elements of the body . . . may be arrested by the use of kephir, or, still better, of sour milk. The latter differs from kephir [an effervescent alcoholic sour milk prepared by the inhabitants of the Caucasus from the milk of goats, sheep, and cows], in that it contains no alcohol, and alcohol in course of time diminishes the vitality of some important cells in the body. The presence of a number of the lactic acid bacteria is inimical to the growth of the bacteria of putrefaction, and so is of great service to the organism."

Hence, Professor Metchnikoff and many of his disciples make a point of drinking some sour milk every day, and the evidence seems to be accumulating in favour of the view that this practice promotes health by "preventing the development of butyric and putrefactive ferments which should be regarded as redoubtable enemies."

The Amides. The group NH_2 is known as the *amido* group, and may replace various other atoms or groups in many organic compounds. Thus we have amido acids very closely allied to the hydroxy acids which we have just been considering. In them the amido group replaces the hydrogen of the acid. Similarly, there are a number of amides in which the amido group occurs. The most familiar of these is *acetamide*, the name of which indicates that it is a derivative of acetic acid. Indeed, it is simply acetic acid of which the hydroxyl has been replaced by the amido group. This acetamide must be regarded both as an acid and a base. It is a base in virtue of its relation to ammonia, and thus, like ammonia, it forms a hydrochloride, the formula of which is that of acetamide plus that of hydrochloric acid. But, on the other hand, it may be regarded as an acid, since certain metals can replace one of the hydrogen atoms of the amido group. It is a white crystalline solid, in this respect resembling all the other amides except formamide, $HCONH_2$, which is a liquid.

Prussic Acid. It can be shown that hydrocyanic acid or prussic acid, with its salts, the cyanides, is related to the amides which we have just been considering. This is an extremely important body from many points of view, and must be carefully considered. Its chemical name indicates its formula, which is HCN. Its popular name indicates its relation to the well-known pigment called *Prussian blue.* Though this body is an extremely powerful poison, it is a very feeble acid. Its history is of very great chemical interest, for it was very carefully worked at by Gay-Lussac, who came to the conclusion that its constituent CN must be regarded as a unit. Subsequently he discovered that this unit exists by itself, and he gave it the name of *cyanogen.* It was from this time that there dates the extremely valuable idea in chemistry of a "compound radical."

Preparation of Prussic Acid. There are several ways in which prussic acid can be prepared, and we may first of all name some of those which are of chemical interest. For instance, it is produced by the distillation of formamide, the body we have just discussed. Remembering the formula of formic acid, the reader will be prepared to believe that that of formamide is $HCONH_2$. Each molecule of this simply splits up into one of prussic acid and one of water. Again, in confirmation of the acid nature of this acid, it can be prepared by decomposition of a cyanide. This is usually done when it is required to be free from water or anhydrous, dry sulphuretted hydrogen acting on dry lead cyanide.

$$H_2S + Pb(CN)_2 = PbS + 2HCN.$$

This process, however, is extremely dangerous, since prussic acid is volatile, and it must, therefore, be carried out under conditions which ensure that the operator is not subjected to the risk of breathing it.

The commercial process for the preparation of this acid depends upon the decomposition of a complex salt which we shall study shortly, and which is known as *ferrocyanide of potassium*, its popular name being *prussiate of potash*. The decomposing agent is sulphuric acid.

Characters of Prussic Acid. At ordinary temperatures the acid is a colourless liquid which, however, boils at only 26·5° C. The vapour, as might be expected, is inflammable, yielding carbonic acid, water, and nitrogen. At not very low temperatures (–15° C.) prussic acid freezes. As prepared by ordinary means, the acid is mixed with water, with which it mixes in all proportions. The acid is extremely difficult to keep, as it is apt to undergo what is called spontaneous decomposition. Though it is chemically an acid, it scarcely reddens blue litmus paper at all. It forms salts with alkalies, but it is so weak that it is incapable of decomposing even an alkaline carbonate. It is thus classified by toxicologists or students of poisons with two other acids, *oxalic* and *carbolic*—later to be studied—which exert their characteristic actions upon the body independently of their acid properties. Unlike sulphuric acid, for instance, they are poisons not because they are acids. Oxalic and carbolic acids possess also the caustic properties typical of acids, but prussic acid, which is a far more deadly poison than either of them, has no caustic properties at all.

Prussic Acid and Living Matter. Prussic acid must by no means be considered the most deadly of poisons so far as its dose is concerned. Quantities of it are constantly given in medicine—in dilution, of course—scores of times greater than would be fatal in the case of many other substances. But it is pre-eminent on account of the rapidity of its toxic action. One drop of the pure acid merely placed within the eye of a dog will kill it instantaneously. This body is a protoplasmic poison—that is to say, it is directly toxic to protoplasm wherever found, whether in the lowliest plant or the highest animal, and yet it does not coagulate proteids such as are found in all protoplasm, nor does it act by withdrawal of water. From our present point of view, we may divide the various salts of this acid into two distinct groups. In general, the single cyanides, such as potassium cyanide, are almost as poisonous as the acid itself. On the other hand, the double cyanides, and also the single cyanides of iron and platinum, have no poisonous properties at all. This fact is easily explained. The toxic cyanides are those which are instantly decomposed by the body, prussic acid itself being liberated. The innocent cyanides are so because they are incapable of decomposition by anything in the body. Such a single cyanide as that of potassium is readily decomposed even by carbonic acid, which abounds everywhere in the body.

Why Prussic Acid is a Poison. A complete chemical explanation can be given of the reason why prussic acid kills every form of living matter. It absolutely and instantaneously arrests that oxidation, without which protoplasm cannot continue to live. Thus, in the case of instantaneous poisoning by prussic acid, the whole of the blood of the body is found to be of a bright colour. It contains nothing but oxyhæmoglobin, the decomposition of which has been entirely arrested by the prussic acid. The poison acts indifferently upon every kind of tissue in the body—alike on the muscles, the glands, the nerve cells, the nerve trunks, and the nerve endings. Its extreme volatility helps to explain the rapidity of its action, but is of importance in regard to the treatment in cases of prussic acid poisoning.

Antidotal Measures. All treatment of these cases is usually futile, but nevertheless occasions may arise in which the readers of this paragraph may save a life if they are energetic enough. The all-important question is one of time in these cases, and what is done must be done quickly. It is usually quite useless to give doses of atropine subcutaneously, for time is not available. Brandy may be accessible, however, and also inhalations of ammonia. But far and away the most important help which can be rendered by the bystander is the performance of artificial respiration. The chemical antidote for prussic acid is of no value in practice. It consists of the administration of a mixture of a ferrous salt, a ferric salt, and caustic potash, with the formation of non-poisonous Prussian blue in the stomach. Even if all these substances were ready at hand, however, they could not avail to neutralise the prussic acid which is instantaneously absorbed from the stomach.

The very marked values of this drug in medicine are due to its local depressing effect upon nervous tissue, which it makes less sensitive. Needless to say, it can be used only in extreme dilution.

Ferrocyanide of Potassium. The important double cyanide known as *ferrocyanide of potassium* is prepared in large quantities by the interaction of metallic iron, carbonate of potash, and many kinds of animal refuse. The salt forms permanent crystals which lose their water on heating, yielding a white powder. We have called it a double cyanide as if it were the combination of potassium cyanide and ferrous cyanide. But it must not so be regarded chemically. It is, rather, a compound of potassium with the complex radical *ferrocyanogen*, which has the formula $Fe(CN)_6$. Its formula is $K_4Fe(CN)_6$. Closely allied to this important salt is the ferricyanide of potassium, which forms red crystals, whereas those of the ferrocyanide are yellow. When these two salts interact with other iron salts they yield richly-coloured bodies which are of value as pigments. *Turnbull's blue* is formed by the mixture of the ferricyanide and a ferrous salt, while *Prussian blue* is formed by the mixture of the ferrocyanide and a ferric salt.

Cyanide of Silver. One of the most important of the metallic cyanides is the cyanide of silver AgCN. This salt is precipitated when nitrate of silver acts on prussic acid. It is a white substance which resembles chloride of silver.

Potassium Cyanide. Cyanide of potassium, which has the formula KCN, may be prepared in various ways. The most common is the action of heat upon the ferrocyanide. It is an extremely unstable body, white and deliquescent. Water, and even the carbonic acid of the air, suffice to decompose it, so that it has the characteristic smell of prussic acid. It also tends to become oxidised in the presence of air, forming the cyanate, which has the formula KCNO. Commercial cyanide of potassium is really a mixture of cyanide and cyanate. It is unfortunately only too easy for this poison to be bought for "photographic purposes," and used for suicide.

Cyanogen. We have already made one or two references to the very important organic compound which is called *cyanogen*. Its correct formula is not CN but $(CN)_2$, the two carbon atoms being united. It is produced most easily by the action of heat upon mercuric cyanide, which splits up into mercury and cyanogen at a temperature below redness. It is worth noting that in this process a solid black residue is always deposited. This appears to consist of molecules which are multiples of that of cyanogen, for when it is heated still further it changes into cyanogen. It is called *paracyanogen*. Cyanogen is a colourless gas with a characteristic odour and poisonous properties. It liquefies at about $-20°$ C., and at a somewhat lower temperature can be solidified. It is somewhat soluble in water and much more so in alcohol, but the solutions, like those of prussic acid, rapidly tend toward decomposition. Cyanogen burns with an extremely beautiful flame, often described as peach blossom in colour, yielding carbonic acid and nitrogen. It does not directly unite with hydrogen so as to form prussic acid. When treated with the halogens, however, it forms a corresponding salt, such as the chloride of cyanogen.

Some reference has previously been made to the extremely suggestive, if erroneous, hypothesis of Pflüger, advanced in 1875. In comparing the living proteid molecule, which is unstable, with the dead proteid molecule, such as that of white of egg, which is stable, Pflüger argued that the difference might be explained by the presence of the radical cyanogen in the former. He suggested that "in the formation of cell substance—*i.e.*, of living proteids—out of food proteid, a change of the latter takes place, the atoms of nitrogen entering into a cyanogen-like relation with the atoms of carbon, probably with the absorption of considerable heat." We know that cyanogen is formed at an incandescent heat; "accordingly," says Pflüger, "nothing is clearer than the possibility of the formation of cyanogen compounds when the earth was wholly or partially in a fiery or heated state. If, now, we consider the immeasurably long time during which the cooling of the earth's surface dragged slowly along, cyanogen, and the compounds that contain cyanogen and hydrocarbon substances, had time and opportunity to indulge extensively their great tendency towards transformation, and to pass over, with the aid of oxygen, and later of water and salts, into that self-destructive proteid, living matter."

Cyanic Acid. Reference has already been made to cyanate of potassium. This is a typical salt of cyanic acid, HCNO. We saw long ago that sulphur and oxygen are closely related to one another, and we have already been provided with many proofs of this relation. Another is furnished by the fact that we know an acid which corresponds precisely to cyanic acid but in which oxygen is replaced by sulphur. This is known as sulpho-cyanic acid and has typical salts—the *sulpho-cyanates*. Potassium sulpho-cyanate is very well known, having the formula KCNS. The ammonium salt is also well known, and both are widely used in chemistry.

Cyanogen and Synthetic Chemistry. We have already observed that cyanogen may be supposed to be involved in the characters of living matter, and now we have to learn that this extremely important compound furnishes a starting place for the synthesis of a very large number of compounds which, using the old terminology, we may call *organic*. If, however, we are to achieve our synthesis from the very beginning, it will be necessary for us to be able to synthesise cyanogen itself. This we can accomplish indirectly by the synthetic production of cyanides, or hydrocyanic acid. For instance, the electric spark, passing through a mixture of acetylene, C_2H_2, and nitrogen, produces prussic acid; cyanide of ammonium is produced by the passage of ammonia over red-hot charcoal; cyanides are also produced by the direct interaction of nitrogen with potassium carbonate and charcoal at white heat.

Continued

MATERIALS IN CARPENTRY

The Properties and Treatment of Timber. Hard and Soft Woods. Carpenters' Ironwork and Its Uses. Metal Accessories

continued from page 3391

By WILLIAM J. HORNER

MEN who have planks supplied to them for workshop treatment require a special knowledge of timber of a rather different nature from those who deal with trees and logs, and their reduction into planks. The information given in most books on the subject is generally of more value to the man in the sawmill than to him who uses timber. A man may know the nature of timber and how it will behave when cut into planks, and yet make lamentable mistakes in using it in construction. On the other hand, he may know nothing about timber and its treatment before it reaches him in the form of seasoned planks, and yet be familiar with all its peculiarities as far as his trade is concerned. This chapter will deal with timber only as far as its characteristics immediately concern the man who has to use it, and will avoid repetition of the information conveyed in the article beginning on page 51.

Tredgold has said that to judge the resistance of timber requires experience, and that this ability is more instinctive in some men than in others. Since Tredgold's time timber as a material has diminished in importance owing to the use of steel for large structural work ; and, moreover, we now rely less on judgment than on calculation. But a good deal of judgment when dealing with timber is still necessary, because it varies so greatly in strength and character.

Grain and Shrinkage. An elementary fact of the first importance in constructions of wood is the paramount influence of the direction of grain. Timber is of a fibrous nature, strong in one direction, and weak in the transverse direction [**33**]. The fibres will separate from each other easily, but they will stand a great deal of tensile or shearing stress. A piece of wood can easily be split in the direction of its grain, but cannot be split at all across the grain. It can be broken across the grain, leaving jagged ends, but if of equal section in both directions, it requires infinitely more power to break it across the grain than with the grain. One of the first considerations, therefore, in all woodwork is the direction in which the grain is to be arranged. The importance of this is increased because strength is not the only thing that has to be considered in deciding the direction of the grain in constructions of wood. It is essential also to take account of another peculiarity of timber. This is that the fibres, which may be considered as a number of small tubes packed side by side, readily shrink or swell according to the amount of moisture in them. This shrinking and swelling takes place only transversely to the grain, leaving the dimensions lengthwise practically unaffected. In most cases it is shrinkage only that the woodworker has to fear, for wood is seldom so dry that it will not shrink further, especially if it be cut and a fresh surface exposed to the atmosphere. The wider a piece of wood is the greater will be the variation in its entire width due to shrinking or swelling. Great width is therefore undesirable, both because it is weak, and because it cannot be kept to a permanent dimension. It is not only weak in the sense that it may easily be split, but unless it be stiffened by transverse pieces, or by being attached to something that is strong enough to hold it straight, it is certain to warp [**34** and **35**]. It will warp because it is practically impossible to place it in conditions that will allow it to shrink without warping.

Moisture in Wood. An equal rate of drying on each side is not so easy to ensure as might be supposed ; but even with that condition granted, the chances are that the wood is already unequally moist, and if it is sawn or planed true while in this condition it will not be true when equally dry throughout. Trees themselves have more moisture or sap near the circumference than at the heart, and the consequence is that planks are unequally filled with sap, which, generally, is not entirely dried out before they are used. Then, in hard woods especially, the grain is often curly and more dense in some parts than in others, with the result that drying proceeds unequally, and the plank twists accordingly. A thin piece of wood is as sensitive to moisture and dryness as a piece of cardboard. If the latter be held to the fire, or if one side be damped, it immediately curls, owing to the contraction or expansion of one side, while the other remains stationary. Timber does not respond quite so quickly, and is affected only across the grain [**35**], where the fibres offer no resistance. Planks are often slightly curved lengthwise, but this is usually the result of being supported at each end and allowed to sag in the middle until a permanent set is attained. Timber can thus be forced to assume any shape it may be bent to. It can also, of course, be forced to remain flat and true, and it is a part of the woodworker's business to know how to arrange the parts of his structures so that not only strength but permanency of form and dimensions shall be secured. Figs. **36**, **37**, and **38** show three different ways in which boards may be cut from a trunk, **36** being the best.

Why a Door is Built Up. The necessity of taking into account these peculiarities of wood makes the building up of woodwork more complex than it otherwise would be. As a familiar example of this we may take an ordinary house door. It measures, say, 7 ft. high by 2 ft. 6 in. wide by $1\frac{1}{2}$ in. thick. If timber did not shrink or

warp, and were equally strong in every direction, the door would simply be made from one piece of stuff $1\frac{1}{2}$ in. thick, or perhaps of two or more pieces, edge to edge, in order to obtain the width. But a door made in that way would not do at all. Its width would vary with the state of the atmosphere, and it would be certain to warp very badly. In addition to these two defects, it would be likely to split lengthwise. It is necessary to frame it together from comparatively narrow pieces arranged so that the grain runs in both directions, and so makes shrinking or splitting practically impossible. The widest places are the panels, but shrinkage in the panels does not affect the exterior dimensions of the door. If the panels were tightly held at their edges there would be a risk of their splitting through shrinkage, but they are merely slipped into their grooves when the door is framed together, and unless there are already incipient cracks in them, they will adjust themselves in the grooves rather than split through shrinking.

An example of shrinkage is shown in **39**, in which a wide piece of wood is screwed or nailed on a frame which cannot shrink with it. The plate of wood has shrunk in width, and, being held by the nails, could not contract freely across its width as it would if unattached. The consequence is that it cracks, and is then free to spread apart at intermediate places. In so wide a piece no care in seasoning the wood could entirely prevent this effect. The cracks could be prevented by using a number of narrow pieces side by side, instead of one wide piece, but a framed and panelled plate would be the only way to prevent variation entirely.

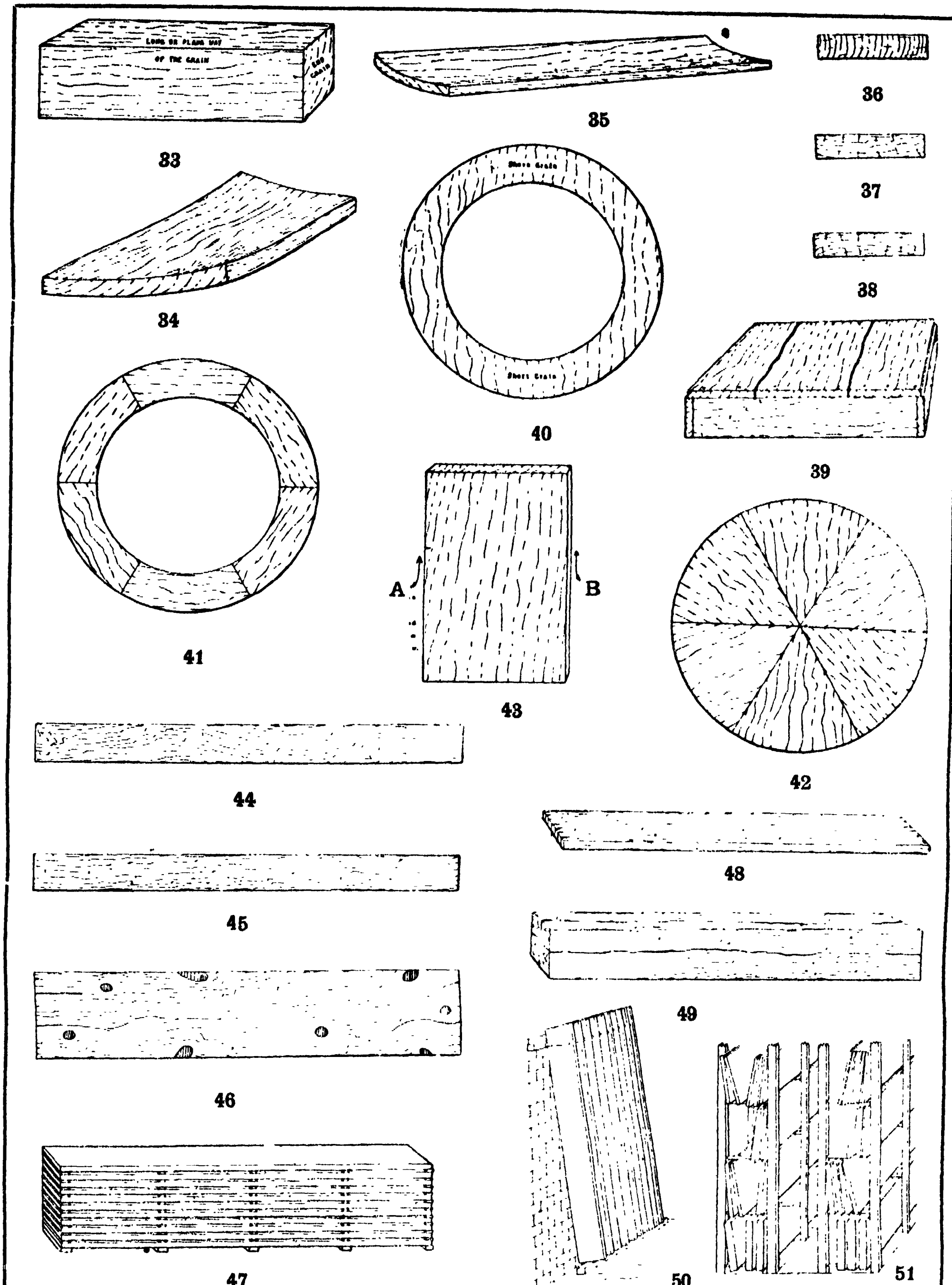
Rings Built in Segments. Figs. **40**, **41**, and **42** show how these weak features in wood necessitate building up in circular work. A ring cut from the solid, as shown in **40**, would be worse than the solid door previously instanced. It would be worse because its interior is cut out, and the short grain is consequently very weak. Such a ring would be built in segments, as shown in **41**, but at least two layers of segments would be employed, so that the end joints of each layer could overlap each other. Otherwise it would be weak at the joints. It is true that such a ring might be more simply made by cutting out two entire rings from the solid, and putting them together with their grain crossed; but the objection to it would be that they would shrink in opposite directions, and overlapping edges would result. A circular plate built as in **42**, even of a number of layers breaking joint with each other, is not so strong a construction as two or more thin plates, cut from the solid and put together with grain crossed, but its advantage is that uniform end grain is presented round its circumference and the plate can never become elliptical through shrinkage.

Properties of Wood. In the behaviour of wood, when it is operated on with tools, there is also a considerable field of knowledge which the woodworker has to acquire. It is necessary to know its weak parts, so as to avoid splitting when boring holes or driving nails. In planing and finishing surfaces, especially if the grain be not straight, it is necessary to avoid tearing the surface up in consequence of planing it against the grain [**43**]. It is necessary to know how and to what extent a piece of wood is likely to shrink or become distorted when a fresh surface is exposed in cutting it, and also how to treat freshly-cut wood to prevent it from warping. Waste should, of course, be avoided as much as possible in marking out and cutting wood, and the good and inferior parts should be used in the places for which they are most suitable. A piece of timber with curly and crossed grain [**44**] is not so strong as a straight-grained piece [**45**], because it is more easily broken across its grain. A piece with a great many knots [**46**] is not suitable for sawing into narrow strips unless the knots can be avoided without much waste, because a knot in a narrow strip naturally diminishes greatly the strength of the strip. Similarly, in a wide piece a shake or crack is a source of weakness, and such a piece would be better sawn up so that the sound pieces on each side of the shake could be used separately. End grain joints are avoided, if possible, because a continuous piece is better and stronger; but joints running with the grain are not objectionable, and if properly made are quite equal to, and in some cases even better, than a solid piece of the full width.

Seasoning. What the carpenter requires to know about timber is only a small section of a vastly wider subject, but it is sufficient for the purposes of his trade. The botanical character and growth of timber trees, and the methods of their conversion into the commercial forms of boards, planks, battens, etc., do not immediately concern him, though it is desirable that he should have some knowledge of these things. When timber comes into his hands it has been through the sawmill, and has undergone a process of seasoning.

Seasoning is simply allowing the cut timber to dry for three or four years before using it, or, alternatively, hastening the removal of the sap and moisture by artificial means. If this were not done it would shrink and warp after being worked up, and if evaporation were prevented by paint or other means it would decay. The natural sap is more objectionable, and takes longer to dry out than water which has penetrated after the wood has been seasoned. One of the methods of artificial seasoning is to place the timber in running water to wash the sap out, and thus leave only water to be dried out of the pores. Another method is to dry quickly by artificial heat, preferably moist, to prevent a too rapid drying of the exterior. The air is generally kept in motion by fans.

Slow natural seasoning is generally considered better than any of the artificial methods, because the latter often have injurious effects on the quality of the wood. The best method of natural seasoning is to stack the timber in sheds to protect it from the weather, and to have free circulation of air. Air space must be allowed between individual pieces, and they should also be arranged so that they are kept forcibly flat and straight. This is generally done



TREATMENT OF TIMBER

33. Difference between plank way of grain and end grain **34.** A piece of wood that has become winding or twisted or warped by unequal strains **35.** A plank become curved through unequal drying **36.** End view of a plank sawn so that the annual rings will stand wear well and shrink least **37.** End view of a plank which would be inclined to shell out in the middle of upper face **38.** End view of a plank with better wearing qualities than 37 but inferior to 36 **39.** Shrinkage in wood causing reduction in width and development of cracks **40.** Example of weakness due to short grain **41.** The strongest form of wood ring **42.** Best method of constructing a wood disc **43.** Wood grain in planing. If planed in the direction of arrow A, the edge would be torn and rough; if planed with the grain in direction of arrow B, edge would not tear up **44.** Crooked grain **45.** Straight grain **46.** Piece with knots, shakes, and curly grain **47.** Boards piled flat with strips between **48.** Small end cracks caused by too rapid drying **49.** Balk with cracks caused by circumferential shrinkage after being squared **50.** Boards stacked on end against a wall **51.** Boards stacked on edge in a rack

by piling them on top of one another and keeping them slightly separated by inserting thin strips between [47]. Balks are generally stacked in squares, with each layer transversely to the next and with considerable spaces between the members of each layer. Deals are often stacked in a pile all longitudinally with each other, but so that they break joint, with spaces between. This latter method is often adopted also for narrow boards, but one of the reasons for this overlapping is to make a steadier pile than would be possible if the spaces between were continuous from top to bottom. Generally, the air is not allowed free access to end grain, because the evaporation of moisture there is so much more rapid, and this often results in splitting at the ends, owing to the wood contracting more rapidly there than farther along [48]. To prevent this the end grain may be painted or greased to close the pores, or strips of wood or hoop iron may be nailed over it. The length of time occupied in natural seasoning depends on the size of the wood and on atmospheric conditions. Generally, timber is not considered fit for carpenter's use till at least two years after being felled and for indoor work considerably more than that. The thorough seasoning required for the more exact work of joinery and cabinet-making, however, is generally assisted by resawing, or further reducing the size of the wood.

Timber as a Material. Timber was undoubtedly one of the very earliest materials employed by man, being easily worked and always ready to hand everywhere. As, too, the requirements of mankind have increased, and his tools become more numerous and specialised, he has been able to use timber more and more extensively, and to utilise it in constructions that would have been impracticable when facilities for its working were less developed. Within the last half century especially the introduction of machines for performing all the common operations has immensely reduced the time and labour involved when such things are done slowly and laboriously by hand. The carpenter still retains his trade, but instead of considering himself competent to undertake anything and everything constructed in wood, he is now only one among many classes of woodworkers, and nearly all the work requiring physical strength rather than brains is done for him by machines—sawing, planing, mortising, tenoning, and the rest.

This, however, has not really lessened the great importance of his craft or the amount of training required for its proper acquisition, nor, probably, the number of carpenters employed; for if the work done by machinery now could be executed only by hand, most of it would not be done at all, because the expense would render it a luxury for the few. The poor would not have wood floors to their houses, nor elaborate and highly-finished wood fittings everywhere.

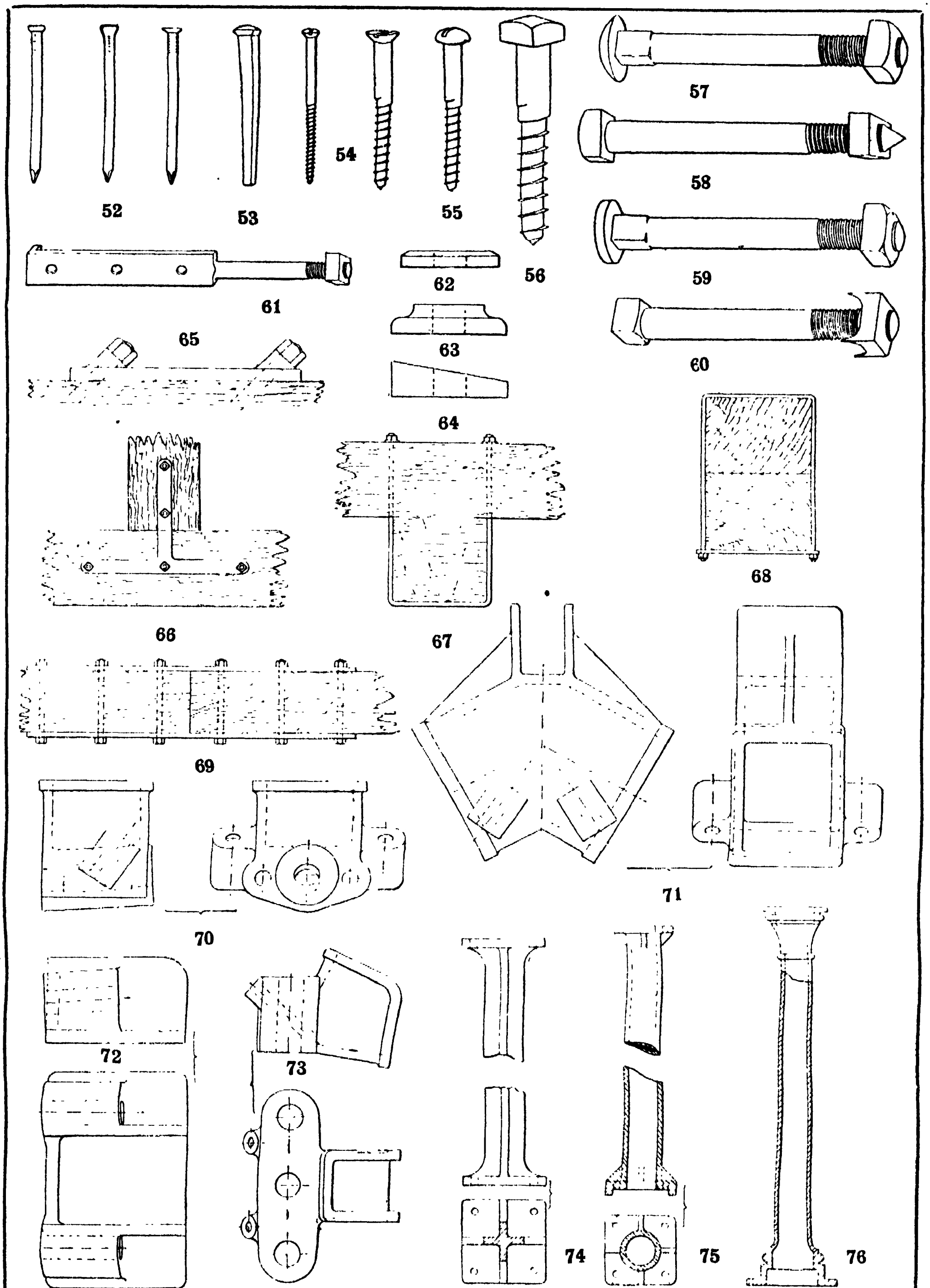
Timber differs from most other materials in the great variation which exists between different kinds, and in the differences in strength between good and indifferent specimens. It is not possible to calculate the resisting power of timber so accurately as is done with most other structural materials. In designing timber structures the sections of the individual parts have usually been decided more by judgment than calculation. In steel and iron, strengths can be calculated from test pieces, and these materials will not deteriorate with age alone, nor are they subject to diseases, as timber is. Hence, too, the reason why a much higher factor of safety must be adopted in using timber than in metal.

Hard and Soft Woods. Wood is termed *hard* or *soft* according to the kind of tree from which it comes, but in both classes there are great differences in degree of hardness. Of these two the hard wood forms the largest section, but carpenters use more soft wood. In order to divide definitely the varieties of trees into the two classes of hard and soft, those with broad leaves are classed as hard, and those with long, narrow leaves as soft. This places some rather hard woods, such as yew, in the soft wood list; but outside of the various kinds of pine there are only a few soft woods, and they are so little used that they are scarcely worth considering. The shape of the leaves seems a detail, but they are typical of the character of the tree. A broad-leaved tree is slow in growth, and does not attain so great a height compared with its circumference as a narrow-leaved tree does. The increased time occupied in its formation generally results in a closer-grained and harder wood being formed. Most of our native trees are hard wood, the oak standing at the head of the list.

Sources of Soft Woods. The important soft woods are all varieties of the pines or coniferous trees, and are imported from North Europe and Canada. Most of our hard wood is imported also, because we have no timber forests in Britain, and could not possibly grow the commonly-used timbers fast enough to keep pace with our rate of consumption.

Formerly, when we had a large home supply of oak, that was the wood most commonly used, and it occupied a more important position than the pine that has taken its place. Now oak occupies a secondary position, especially as most of this wood is now imported, and is not considered equal to British oak. Against this difference in the kind of wood now most popular, however, we must place the fact that for much of the work for which oak was formerly used, such as shipbuilding and the framework of houses, steel and masonry have been substituted.

Recommendations of Soft Wood. The reason why the soft woods are popular is because they are cheap, light, straight-grained, and easily worked; while for many purposes they are equal to the hard woods. The latter, however, differ so much in their physical characteristics, that each is best adapted for special purposes, and consequently they serve these purposes better than soft woods, though no single hard wood has so wide a range of usefulness as soft. In very many cases also hard wood is used solely for the sake of appearance. This is the case to a very large extent in cabinet-making. In ordinary carpentry hard



CARPENTRY IRON WORK

52. Varieties of wire nails **53.** Cut nail **54.** Iron wood screws **55.** Round-headed wood screw **56.** Coach screw **57.** Ordinary or "cup square square" bolt and nut **58.** Rail or "square round square" bolt and nut **59.** Cheese-headed carriage bolt **60.** Fang bolt **61.** Strap bolt **62.** Wrot iron washer **63.** Cast-iron washer **64.** Bevelled washer **65.** Cast-iron washer for two bolts **66.** T-strap **67** and **68.** Stirrups **69.** Fishplates **70-73.** Typical cast-iron shoes for timber roof **74.** Stanchion **75.** Plain column **76.** Column with moulded base and capital

wood is used only because of its superior durability and strength, or of some characteristic that specially adapts it for the purpose in view, as, for instance, the use of ash where a flexible wood is required. But the fact remains that the hard woods used by the carpenter are very limited in number. The chief, and by far the most important, is oak. The bulk of his work is done in soft materials, of which there are several varieties included under the generic names of pine and firwood.

The plate facing page 56 illustrates the grains of a large variety of hard and soft woods.

Commercial Forms of Timber. Timber in its commercial forms is usually of definite thicknesses and widths, and various names are applied to it according to these dimensions. If we consider them in the order of their size we have first the *balk*, or *whole* timber, or *log*. The term log really means the unsquared trunk of a tree, but is sometimes used in the same sense as balk, which means a squared trunk. The term is applicable to any large piece of timber, whether it represents the entire trunk of a tree or not. Unlike most of the other forms of timber, the dimensions are not of a fixed character. In length a balk may average 30 ft., but occasionally may be more than twice as long. Timbers of smaller section, such as boards, etc., range in length from about 8 ft. to 20 ft., 12 ft. being a common dimension. They are cut thus because great lengths are seldom required, except in engineer's work, and are not so convenient for handling. Balks were formerly squared with an adze, and to a considerable extent are still, but there cannot be much doubt that ultimately the saw only will be used, and the adze become obsolete for the purpose.

Next in size is a piece of timber called a *flitch*. This is one-half of a squared log, or balk, that has been sawn down the middle lengthways. In section its width is consequently about twice its thickness. Next in size comes a *plank*. This term is often loosely used to describe timber that strictly comes under the name of *board*. The difference between the two is that a plank must be over 2 in. thick and over 10 in. wide, while a board must be less than 2 in. thick, and may be any width over 6 in. *Deals* and *battens* come in regard to size between planks and boards. They are thick, but comparatively narrow. A deal measures from 2 in. to 4 in. thick by 9 in. wide. A batten is of about the same proportion, but rather smaller in width and thickness. *Quartering* is produced by sawing deals into two, three, or four strips. *Scantling* is a general term applied to sawn wood of any size. *Ends* are short pieces of plank, deal, or batten. In addition to these terms for sawn timber, there are *poles* and *masts*, distinguished from each other by their diameters, the former being less than 8 in. in diameter, and the latter more. These two terms are sometimes qualified to indicate further particulars.

Market Quantities. There are also names for quantities of timber. It is sold by the *standard*, which is 120 deals; by the *load*, which is 50 cub. ft.; by the *superficial foot*, the thickness being reckoned at 1 in.; by the *foot run*, when width and thickness are specified; or in some valuable hard woods by *weight*. *Match-boarding* and *flooring* is sold by the square of 100 superficial ft., or 10 ft. each way.

The foregoing are a few elementary facts, but behind them there is a great deal of complication and confusion through differences in sizes and methods of measurement. These things, however, concern the importer and dealer more than the carpenter. The standard of deals (nominally known as a 100, but really 120) varies in number according to the size of the deals. In the London standard the deal measures 12 ft. by 9 in. by 3 in. In the St. Petersburg standard, which is rather more commonly used than the London one, the deal is 12 ft. by 11 in. by 3 in., and there are only 60 to the 100. There are also a number of other standards, and the consequence is that in buying and selling timber the kind of standard has to be specified, and frequent translations made from one into another. No matter what the size of the deals, however, the cubic contents of each standard is always the same, with unimportant exceptions. The number of cubic feet in a St. Petersburg standard is 165, and in the London standard 270. In the measurement of balks there are two different methods—the *string* and the *caliper*—which do not give similar results. The nominal dimensions of sawn timber may also differ from the actual dimensions. Imported boards are usually a trifle over the specified thickness and home-sawn boards are usually under it. This is because in the latter case so many boards are sawn from a deal, and no allowance is made for the amount lost in sawdust. In thin boards this difficulty is sometimes got over by designating them as 4 cut, 12 cut, etc., according to the number of saw-cuts made in cutting a 3 in. deal into boards of that thickness.

There is now much greater variety in the market sizes of sawn timber than was formerly the case, and the carpenter can buy practically what he wants without having to reduce it himself from larger material, or use material of one particular dimension, when a slightly different size would suit his purpose better.

Qualities of Timber. Quality is specified by dividing timber into the classes of firsts, seconds, thirds, fourths, fifths, and sixths, the last being the poorest. *Firsts* are sometimes qualified also by adjectives, such as *prime*, *selected*, *sound*, *dry*, etc.

This is done in order to arrange a scale of prices according to quality, and also because in specifications it is often desirable to fix a standard of quality below which the contractor must not go. Otherwise, it would be superfluous to class timber, when every man who is familiar with it is capable of judging the quality of any piece individually.

The carpenter may generally assume that timber is not defective through a tree being felled before it was near maturity, or so late in life that the heart was decaying; and he can also assume that its after treatment, conversion, and seasoning has been carried out as carefully

and correctly as was practicable, though the latter may often not be sufficiently complete to fit the wood for interior work. It is not often either that converted timber has any sapwood (the inferior outer portion of the trunk) attached to it. The defects to be looked for are of a natural character that could not be avoided. Where strength is required, straight grain [**45**], instead of crooked [**44**], and freedom from knots and shakes [**46**] or cracks, must be regarded as essential in a piece of wood of first-rate quality. Straight grain in soft wood is the rule rather than the exception. Knots are very objectionable, but often have to be tolerated, in spruce wood especially, because it is difficult to get boards without knots. Cracks generally occur as the wood dries in seasoning, and often cannot be prevented. They are objectionable, but whether they are a serious defect or not depends on the way in which the wood is to be used. A board with a crack in it is not sound, as a board; but the wood on both sides of the crack may be satisfactory, and it may be glued, or, with a little waste, cut, and the pieces on each side used separately.

Defects in Balks. In large balks there are sometimes defects that seriously impair the strength if the balk is to be used entire, or that cause waste in cutting up. Often the extent of the defects cannot be seen in the balk. There are several forms of shake or crack that occur in the trunk before the tree is felled. These may be either radial from the centre, or circumferential, between the annual rings. The former are known as *heart* and *starshakes*, the latter as *cup* or *ring shakes*. The precise cause or causes of these shakes are not certain, but they occur only in large trees, and are supposed to be due to interior stresses between the matured heartwood and the growing sapwood. There is usually nothing to indicate their presence until the tree has been felled, and they can be seen in the end grain. These, however, are not so common as shakes which develop from the exterior [**49**] after the tree is felled. In the trunk these may radiate from the outside towards the centre, or, as is very common in deals and boards, they may start at the ends. They are due to shrinkage caused by the too rapid drying of the outer wood. Precautions are taken to prevent them, but often they cannot be entirely obviated.

Cross Grain, Knots, and Shakes. Cross grain, knots, and shakes are the three chief defects to look for in judging sawn wood. But a board may not have these defects, and yet be in an unsound state in consequence of disease or of variations in quality. Or it may be so wet that, except for rough out-of-door work, it is unfit for immediate use. Timber becomes diseased locally through injury occurring to the bark of the growing tree, and from incipient decay due to numerous causes. It becomes uneven in texture and in degree of strength from variable density of the fibres and from unequal nourishment, or other variable conditions, as, for instance, persistent sunshine or wind chiefly on one side of the trunk. These variations, of course, are less marked in individual trunks than in separate trees which are grown on different soils, and either isolated or in close proximity to other trees. This last factor has a considerable effect on the character of the tree by forcing its upward growth, and more or less protecting it from the weather. Timber also, after it is felled, may be deteriorated by wood-boring insects.

There are also a number of diseases to which timber is subject. They are all indicated by discoloration or destruction of the fibres. The commonest of these is dry rot. This generally occurs in old timber that has been a long time in damp, warm, ill-ventilated situations. It is the result of a fungoid development that eats away the substance of the wood, leaving it in a dry, powdery condition, with a musty odour.

Preservation of Timber. In finished work it is a very common practice to protect wood from the atmosphere and the deteriorating effects of alternating dampness and dryness by coating the surface with paint, tar, varnish, or other preservatives. Other methods are employed to preserve the entire substance instead of affording only a protecting coat on the surface. The chief among these is *creosoting*, which is the forcible injection of oil of tar or creosote into the pores of the wood. This renders it poisonous to all forms of parasitic life, and effectually preserves the wood. But the objections to it are that it blackens and makes the wood highly inflammable, and for many purposes the smell of the tar is objectionable. It is used chiefly for out-of-door purposes where the wood comes into contact with the ground. Railway sleepers and paving blocks for streets are generally creosoted. There are several other less popular processes, but the principle in most is to preserve the wood by making it poisonous to parasitic life. Only a very small proportion of the wood used by carpenters is subjected to any preserving process, and it is only when wood is required to endure very trying conditions that there is any necessity for it, or any appreciable advantage in it.

Shipping Marks. These are marks chalked, painted, stamped, branded, or scribed on the ends of balks, deals, and most imported timber of any form. They indicate quality, the place of origin, the shipper's initials or private mark, and sometimes those of the person to whom they are consigned. Lists of them are contained in most publications dealing with the timber and building trades. Shippers frequently change their marks, and new firms are continually coming into existence, so that no list can be taken as permanently correct and complete. They concern the timber merchant more than the carpenter.

Storage of Timber. Timber stored in or near the shop for immediate use need not be stacked so methodically as for seasoning, but it should not be allowed to lie in positions that tend to strain or bend it: nor is it wise to let boards remain for a long time with one side exposed to the atmosphere and the other not. It is generally inadvisable to pile boards on

top of one another, because of the difficulty of selection and withdrawal, when only the top ones are fully visible. It is better either to stand them on end against a wall [50], preferably with their upper ends in a rack, which keeps them edge outwards, or to stack them side by side on their edges [51], in a horizontal position in a rack. If kept lying in piles on their flat faces it is necessary to allow an air space between each by inserting strips [47], hence termed *stripping.*

If any piece be badly curved or twisted it should be subjected to treatment that bends it the opposite way; and if left like this for a few days or weeks it will probably remain straight, or nearly so, afterwards. Boards that are thus distorted should also, when possible, be selected for cutting into small pieces, because the distortion then may be reduced to nothing. Boards with knots, shakes, or other defects should be selected with a view to sawing them up and working them for parts where inferior stuff may be used, and the best pieces kept for parts where good quality is imperative.

Metal Accessories. Timber could not be used so generally or so effectively were it not secured and reinforced by suitable metal connections. These are chiefly of wrought iron, and their character depends on the class of carpentry for which they are used. In the heaviest work bolts and tie rods are very commonly employed for purposes where nails and pinned or dowelled joints would be sufficient if the work was of lighter character. Straps and stirrups are generally alternatives to bolts, and are often employed to avoid weakening the timber by boring holes for bolts.

Where whole timbers and balks enter into construction, castings and flat plates of wrought iron called *fishplates* are often employed in conjunction with bolts for holding joints together. For lighter work coach screws are common, and for the lightest, nails, screws, and glue.

Nails. Nails are the most common and simplest means of uniting pieces of wood. They are driven with a hammer through the first piece and their ends extend some distance into the connected piece; they hold by friction or the compressive force of the surrounding wood. Sometimes when the material is not thick and a strong hold is required nails of greater length than the total thickness are used, and their projecting ends are *clinched*, or bent over and hammered flush with the surface. But generally they should not be long enough for their points to come through the far side of the material.

Nails are sold in great variety, not only of size but of kind. There are consequently a number of names applied to them to qualify the term nail. When over about 5 in. in length they are called *spikes.* At the other extreme, in the small sizes, they are oftener known as *pins, brads,* or *sprigs.* The larger nails are sold by weight. Some small wire nails are sold in packets by count. The wire nail [52] is the most commonly employed and favourite form, especially when medium and small sizes are required. At one time the cut nail [53] was the most popular. It is either of steel or wrought iron, rectangular in section, with a slight amount of taper, and increased in size at the head.

Wire nails are made round, oval, and square in section; the last-named form is not much used, nor the oval so much as the round. They are parallel, with pointed ends and small heads, and are made in sizes ranging from about ¼ in. to 6 in. long. They vary in stoutness according to the work for which they are required.

Screws. In any other woodwork but carpentry screws [54] would come before nails in order of importance. Screws are superior to nails for all purposes, but they are more expensive and their insertion takes longer. They not only hold better when in place, but they can easily be withdrawn without injury to the work, and it is also often an advantage to be able to insert them without jarring the work as the driving of nails does. Screws are not made in quite so great a variety of form and character as nails, though their lengths are about the same. The tendency in recent years has been to reduce screws from many types to a few. The ordinary type of screw is pointed at the end, threaded for nearly two-thirds of its length, with a head tapering to about twice the diameter of the shank, and flat on the top. The chief variation from this is in having the head convex [55] instead of flat on the top, and a square shoulder instead of a bevelled one on the under side. This variation is only made to adapt the screw for purposes where there is an objection to sinking the head flush with the surface of the work. Screws are known by their lengths and sizes. They range from ¼ in. to 6 in. in length, and up to 3 in. each occurs in about ten different diameters, the extremes of which for a 3 in. screw are shown in **54**. These diameters are known by numbers which are printed on the packets in which the screws are sold.

In order to distinguish the above from screws used for metal work they are called *wood screws*, and in Scotland *screw nails.* Their threads differ from those for metal in being farther apart, deeper, and thinner. This is necessary, because wood is a weak substance compared with metal, and no matter how thin and wide apart the threads on the screw are, they are still a great deal stronger than the intervening wood when the screw is in place.

Coach Screws. Coach screws [56] differ from ordinary screws in having square heads, like bolts, instead of flat slotted heads. They are turned with a spanner instead of a screwdriver, and are also a larger and stouter type.

Bolts. Bolts [57 to 61] are used in cases where screws threaded into the wood are not considered sufficiently strong to hold the parts together. Bolts go entirely through and hold the parts by the pressure which the head and nut exercise when the latter is screwed up. Large washers [62 to 65] are always used with bolts for wood, and the heads and nuts are usually square instead of hexagonal. In most cases also a short portion of the shank next to the head

is square [57 and 59] to prevent the bolt from turning with the nut. When long bolts are specially made for a job they are often pieces of iron rod cut to length and threaded for nuts at both ends.

Fig. 60 is a *fang* bolt, the " fangs " or teeth of the nut gripping in the wood while the head is being turned. They therefore fulfil a similar function to the square necks in 57 and 59. Fig. 61 is a *strap* bolt, which is employed for attachment to the flat sides of timbers, when other modes of fastening would not be available, or so secure.

Besides holding parts together, long bolts sometimes serve the additional purpose of strengthening the timber with which they run parallel. In frame work they are often put through, or close to the under side of rails and cross pieces, and they thus support and stiffen the horizontal timber, and also hold the vertical parts of the frame together. *Door bolts*, *tower bolts*, or *socket bolts* are a different article, used for locking doors, and have nothing in common with screw bolts.

Figs. 62 and 63 are *parallel washers*, 62 being in wrought iron, or steel, 63 cast from a pattern. Fig. 64 is usually cast, and is bevelled to suit bolts that do not stand squarely with the faces of their timbers. Fig. 65 is a cast iron washer for two bolts, being preferable to single small washers.

Tie Rods. Tie rods fulfil a duty akin to that of bolts, both being in tension. They are not necessarily provided with heads like bolts, and in some few instances they may be tightened by a cottar instead of a nut. They are distinguished from bolts chiefly by their greater length and the fact that they are supposed to tie distant parts together rather than to go through solid material. They are used to a great extent in roof work.

Straps. Straps are pieces of thin rod iron of rectangular section, sometimes threaded at the ends for nuts, and bent to fit the pieces of timber that are to be held by them. They thus bind parts together rather more securely than bolts, and render it unnecessary to weaken the timber by boring holes. When used to support beams they are called *stirrups*. In a simpler form they are merely flat strips of iron, often with branches, that lie flat on the surface of timbers [66] and hold them together with their faces flush. Figs. 67 and 68 are stirrups.

Fishplates. Fishplates are flat plates of metal [69] which are bolted to the sides of large timbers in order to hold a joint together and keep the faces flush and in line. They are generally used in pairs, one on each side of the timber, and bolts pass through as in the case of shoes. The plates are generally the full width of the timber, and in length about six times the depth of the timber between them.

Cast-iron Shoes. Cast-iron shoes [70-73] have to be made from wood patterns specially made to suit the work in hand. They usually enclose and hold together the ends of two or more large pieces of timber that meet at an angle, and that could not be substantially held by bolts or straps alone. The castings have to be made to the correct angle and size to fit the timbers, and they are held by bolts which go through both casting and wood. These castings are typical of other forms which enter largely into the heavy carpentry of roofs. The pattern work is not difficult when the principles of the craft have been mastered, and a handy man might often be entrusted with such work preferably to putting it out.

Another class of work often used by carpenters dealing with shop and warehouse building is illustrated by the stanchions [74] and columns [75 and 76]. The pattern work for these might be done by an intelligent man. The important point in the design of such work is the firm fixing of the top and bottom with broad, bracketed flanges. These prevent risk of the stresses coming in any direction except right through the axis or centre, which would have the effect of bending instead of crushing the stanchion or column. It is also well to cast joggles on one flange [75], or both flanges, to be let into the masonry foundations. Information respecting pattern work and founding will be found in the course of Mechanical Engineering.

Miscellaneous Requirements. Besides the articles already mentioned, there are a number that are more in the nature of fittings or appurtenances, and are used more in joinery and cabinet-making than in carpentry; and if we go far enough we come to a large class of more or less ornamental metal work used only by cabinet-makers. Among those used by carpenters, the most important are hinges, locks, and handles. Hinges are of two types: *butt* and *strap*, the name generally applied to the latter being *cross-garnet*, or *tee* hinges. The butt hinges are intended to be sunk into the surface of the wood, and consequently they have plain, square edges which extend only a short distance from the pivot or pin. They are more commonly used than the cross-garnet type. The latter are used chiefly for gates and ledged doors. The plates or flaps of the hinge extend a considerable distance in order to stiffen the wood and obtain a stronger hold on it. Locks are made in great variety. They differ in character according to whether they are intended for doors, cupboards, or drawers. Door locks generally have to be either right or left-hand, to suit the door, the only exception being in a few kinds of lock that will suit either hand. Unless mortised into the door, a lock is screwed to the inside. Handles are used for a great variety of purposes, and vary greatly in form. They usually have to be screwed to the wood.

Continued

THE COLONIAL SERVICES

Conditions of Entry and Service in Clerical and Administrative, Railway, and Police Appointments in British Colonies

By ERNEST A. CARR

As a general rule, the young Briton in quest of a career in some portion of our Empire overseas would be well advised to turn his attention to private enterprise, whether farming, mining, commerce, or the professions, rather than to seek the services of the Colonial Governments. A moment's reflection will suffice to show the reason of this. Most of the governing bodies, it has already been pointed out, can obtain from local sources an ample supply of suitable material, and have, therefore, no need to turn to the Mother Country for recruits. This is especially true in respect of the larger and older branches of the Empire—Canada, Cape Colony, Australia, and New Zealand, for example—in which a new generation has sprung up on the soil to contest with immigrant residents such vacancies as arise from time to time in the official ranks.

An Authoritative Warning. These facts have led the Emigrants' Information Office, a Government bureau controlled by the Colonial Department, to issue a warning on the subject. In the preface to its "Handbook on Professional Employment in the Colonies"—a very valuable work which may be obtained, post free for threepence, from 31, Broadway, Westminster, S.W.—it is officially stated that: "Candidates from this country stand very little chance against persons on the spot of obtaining appointments in the Civil Service. Even telegraphists, railway officials and employees are now generally trained in the Colonies. There is, therefore, very little inducement for a person to emigrate on the chance of obtaining an appointment under a Colonial Government."

Apart from India and our Eastern possessions, which have been specially considered, the principal exceptions to the above general rule arise where certain Colonies, owing to the lack of training centres, the smallness of their white population, or other local causes, are unable to furnish enough qualified candidates for their own requirements. We shall therefore pass in review the various openings thus afforded to aspirants from Great Britain, and for our readers' convenience these will be discussed calling by calling, instead of grouping them according to locality.

Clerical and Administrative Posts. In this branch of the public service there is practically no Colonial demand for British candidates, and in general no opportunity is afforded them of obtaining an appointment before quitting the home country, while in several instances they are specially excluded in favour of local applicants. There is, however, an important exception on behalf of students from the British Universities who have failed to pass the contest for the Indian Civil or Police Services, or for Eastern Cadetships. These candidates may often secure good appointments on the West African Coast, or elsewhere, by applying to the Colonial Office, Downing Street, S.W. The posts thus available include cadetships for the grade of assistant district commissioner for the Gold Coast, with an initial salary of £250, and excellent prospects up to £2,000 or more. Such students are also selected sometimes by the Foreign Office for administrative posts in Egypt and British East and Central Africa, and by the British South Africa Company for their Rhodesian territory.

On the other hand, the clerical service of Canada is practically restricted to persons brought up in the Dominion, or able to enlist local influence on their behalf. The Government regulations in Queensland require candidates for ordinary appointments to have resided for twelve months in the State; and the New Zealand authorities expressly seek to dissuade applicants from going out to that country with the idea of entering its clerical service. Other Colonies are no less discouraging. The Agent-General of Victoria has courteously acquainted us that "very few vacancies have been occurring in the Victorian public service for some years past, and when they do, it is found that the local supply is more than equal to the demand. There are large numbers of applicants whose names have been recorded for some years past awaiting vacancies." For similar reasons, the Civil authorities in Cape Colony have suspended the entrance examinations, and the Transvaal Government notifies that "applications must be made in the Colony, and there is an ample supply of local candidates for the lower branches of the service, who generally have the preference."

Incurable optimists who are not daunted from emigration by these and similar reports, will find in the "Professional Handbook" the conditions of entrance for the clerical service of the various Colonies.

Railway Posts. Instead of being private enterprises, as in this country, the great majority of Colonial railways belong to the Governments, and, despite the allusion to railways already quoted from the "Handbook," these offer very much better chances of employment for a trained official than are afforded by the clerical services.

To enumerate here the various rates of pay for railway men in each of the likely Colonies would occupy an unwarrantable space. These figures can be learnt on application to the Emigrants' Information Office, or to the several

Colonial agents in London. For our present purpose, a brief indication of the prospects afforded to men from home will suffice.

South Africa. On the State railways in Cape Colony there is no demand for office clerks or artisans, but goods clerks and mechanics are sometimes engaged in England through the Agent-General for the Colony, 100, Victoria Street, S.W. The engagements are usually for three years, with payment of the passage out. Fitters are paid 10s. a day, and carpenters a little more: but it should be remembered that money at the Cape has only about three-fifths of the purchasing value it has in England. For the Natal railways, platelayers and signalmen, fitters, coachsmiths, and hammermen, are wanted from time to time—the first two classes receiving £10 to £17 monthly, and the others 9s. to 13s. a day. But these situations are generally advertised in England, and there is considerable risk in going out without a definite prospect of employment. The staff of guards, clerks, and checkers, on the other hand, is recruited on the spot, and experienced men who have gone out at a venture have as good chances of engagement as those who are Colonial born.

Australia. The rates of pay for railway employees in Australia and New Zealand are generally good, and the hours of duty light—from 48 to 57 weekly—but from every part of the Colony there comes practically the same report of the sufficiency of local candidates. Thus, the Government railways and tramcars of New South Wales employ a staff of nearly 18,000 men and boys, but openings for applicants from England rarely occur; the Victorian authorities notify that "there are always many more candidates than there are vacancies for them"; and the regulations in Tasmania and Western Australia practically prohibit the engagement of drivers, firemen, and certain other railway servants from outside sources. As a general rule, candidates for permanent employment must be under 35 years of age, and able to pass a medical examination. For clerks and superior officers an educational test is also usually prescribed.

The Canadian railways, like those under the Southern Cross, are officially reported to afford "little or no opening for men from England." But such announcements are intended only to discourage anything like a general movement to the regions concerned. Casual vacancies occur for which capable men, who have been trained on British railways, are in frequent request; and while an engagement before leaving home is highly desirable—and for heads of families is, indeed, imperative—these warnings need not daunt an efficient young railwayman without encumbrances from trying his fortunes in any Colony which, unlike Western Australia, has no prohibitive regulations. He should not take such a step, however, unless he has a little capital on which to live while seeking a post, nor without consulting the experts of the Emigrants' Information Office as to the likeliest field of employment.

Police Appointments. Our Colonial police are, in some few instances, municipal servants—as at Cape Town and Durban, for example. Most of the townships, however, are too small and scattered to maintain separate forces, and police control is therefore usually exercised by the Government of the Colony.

The life of a police trooper in the Colonies is at least as hard as in the home country, his prospects of promotion are generally but little better, and the increased cost of living often renders his higher wages an apparent rather than a real advantage. On the other hand, the semi-military duties of many Colonial forces, the chances they offer of sport and adventure, and that "call of the wild" which the great lonely spaces of the Empire utter to the imaginative ear, give these services an attraction not to be measured in terms of self-interest, and draw into their ranks many men whom the prospect of town or provincial police duty at home would repel.

The South African Constabulary. This body is engaged in police duties in the Transvaal and Orange River Colony, but in time of war may be employed for military purposes. It is sometimes recruited in England, but this has ceased for the present, and candidates must now make written application to the Chief Staff Officer at Johannesburg. Persons resident in the United Kingdom may apply, on the understanding that if approved they must pay their own travelling expenses to South Africa. They should state their age, height, chest measurement and weight, mention their qualifications, and enclose copies of their testimonials, including two from gentlemen of position, one of them a magistrate. The standard of height is 5 ft. 6 in., and the age limits are 20 and 35. Recruits are engaged for three years, with a provision for extended service. In addition to free quarters, rations, clothing, and equipment, and a horse when required for duty, members of the constabulary receive pay ranging from 5s. a day for constables to 10s. for sergeant-majors and 15s. for warrant officers. Commissions are obtainable from the ranks.

The London Staff Officer—from whom further particulars are to be obtained at King's Court, Broadway, Westminster, S.W.—informs us that in his opinion the conditions of service in this corps will probably be changed when responsible government is established in the two Colonies concerned.

Rhodesian Forces. The British South African Police are a mounted force employed, under the control of the Imperial Government, in maintaining order in Southern Rhodesia. Non-commissioned officers and men are recruited locally, and sometimes by advertisement in England. Recruits must be at least 20 years of age and—unless they have served in another police force—not more than 25. They must be of good character, able to ride and shoot, between 5 ft. 6 in. and 5 ft. 10 in. in stature, and of proportionate build. Officers are occasionally sent out from England, but are usually appointed

in South Africa. The rates of pay are as follows: Troopers, 5s. a day; sergeants, 6s. to 8s.; sergeant-majors, 12s. 6d.; commissioned officers, 15s. 6d. to 30s. and upwards—in each case with free quarters and rations.

The Southern Rhodesian Constabulary are employed as civil police in the towns, and are recruited at Salisbury, at Bulawayo, and occasionally in London. Men enrolled in England receive 2s. 6d. a day from the day of sailing, and are provided with a passage to South Africa, the cost of which they must meet by monthly deductions from their pay. Constables are paid 8s. to 10s. a day; detectives and sergeants, 12s. to 16s.; with free rations and equipment, but no quarters. The commissioned ranks receive from £404 to £500, and are filled by promotion from the N.C.O.'s.

Further particulars as to either force may be had of the British South Africa Company, 2, London Wall, E.C., who will always inform applicants whether recruiting is proceeding in England.

Cape Mounted Police. This is a semi-military force much resembling the South African Constabulary in its constitution. It is equally liable to army duties in case of emergency, the term of service is identical, the rates of pay and allowances are very similar, and the same physical standard is prescribed for recruits, but wider age limits are fixed—namely, 18 to 30 years. As recruiting in England has been suspended, applications for enrolment should be addressed to the Commissioners of the force, at Cape Town.

Cape Town and Durban Forces. When home recruiting is in progress for the first of these bodies, men are engaged by the Agent-General for Cape Colony, who will supply all requisite information on the subject. Constables in the Cape Town corps are paid £110, £125, and £140 during the three years of their engagement, with free quarters and uniform. The Durban Police Force is available to suitable applicants from the United Kingdom, the conditions of entrance prescribing 5 ft. 9 in. as the minimum height and 35 as the maximum age. Preference is always given to unmarried men. Candidates from this country should write for instructions to the Superintendent at Durban. The pay is £132 a year for constables, rising in two years to £144; and sergeants receive £162. Messing and quarters cost about £4 a month.

Natal Police. The local supply of recruits is generally sufficient to replace losses. When enlistment is open in England it is undertaken by the Agent-General for Natal (26, Victoria Street, S.W.). Recruits, who must be between 19 and 25 years of age and not less than 5 ft. 7 in. nor more than 6 ft. in height, are enrolled for three years, with the option of renewal. Constables receive 7s. to 8s. a day, with quarters; sergeants, 9s. to 10s.; and sergeant-majors, 11s. In the higher grades, which are filled by promotion, salaries range from £275 to £550.

Australia and New Zealand. In the Australian States, as in New Zealand, candidates must apply personally at the police headquarters in each Colony, and there is no demand for men from England. It would therefore be useless to detail the conditions of service in the several forces; they may be found by the curious in the Emigrants' Handbook, to which we have already referred.

Canada and the N.-W. Mounted Police. Even more exclusive than in Australia are the conditions of British Columbia, where at least a year's residence must precede any application for police employment.

The Royal North-West Mounted Police Force, however, is more readily accessible to English candidates. This distinguished police corps attracts far more British than Canadian recruits; and although all would-be entrants must present themselves in the Dominion for enlistment, a wise provision of the Commissioner enables them to make fairly certain of their chances before incurring the expense of the journey. On applying to that official at Regina, N.W.T., a blank medical certificate can be obtained, together with information as the the existence of vacancies, the standard of requirements, and the terms on which troopers are engaged. By returning the medical form filled in by a local doctor, a candidate residing in the United Kingdom can ascertain from the authorities his prospects of acceptance or rejection on the score of health.

The terms of service admit only single men between the ages of 22 and 40 who are active and able-bodied, and of excellent character. They must be able to read and write, and must understand the care of horses, and be good riders. The minimum height is 5 ft. 8 in., the chest measurement must be 35 in., or more, and the weight must not exceed 175 lb. Constables are enrolled for five years, and receive 60 cents a day, rising to 1 dol., with rations. Non-commissioned officers draw from 1 dol. 10 cents to 2 dol. a day.

The acting adjutant of the force, to whose courtesy we are indebted for much of the above information, concludes his letter intimating the existence of vacancies with the following useful remarks to candidates: "Applicants must be perfectly sound from a medical standpoint and have certificates of exemplary character. Intending recruits have to report at Regina at their own expense and be prepared to undergo a very strict medical examination by our own surgeon. They must assume all risks. Young men of about 22 years of age, well educated, and of strictly temperate habits, are most suitable for our service. In fact, intemperance is suppressed with a stern hand."

The Crown Colonies and Uganda. Candidates for police posts in Uganda or the East African Protectorate should apply to the Secretary of State for the Colonies. The appointment of officers of the police forces of the Crown Colonies is in the hands of the same official, and application should be made to his private secretary at the Colonial Office. The rank and file in these latter Colonies are, of course, natives.

Continued

DAIRY FARMING

Modern Dairying on the Continent and in England. How Production of Milk, Cream, Cheese, Butter, and Preserved Milk can be Improved. Tuberculosis

Continued from page 3471

By Professor JAMES LONG

THE art of dairying, like those branches of science which are playing such an important part in its development, was practically unknown to the agricultural world a quarter of a century ago. It was, in fact, impossible to obtain information in this country with regard to many of the features of successful practice as regards both butter and cheese manufacture which are now common property.

England Behind the Times. It is, however, almost proverbial that in some countries on the Continent the work accomplished was far in advance of our own, while investigation was proceeding upon definite lines, and scientific men were at work upon problems which were not even dreamt of in this country. We possessed neither the equipment for such work nor the men to undertake it. Indeed, at the present time, although large numbers of young men have been trained in the more recently established colleges and dairy schools, little has been done either in the form of demonstration or investigation, and we are, therefore, compelled to rely to a very large extent upon what is accomplished in America and on the Continent for many of the most important facts in relation to dairy science.

Modern dairying owes its incentive in large measure to the action of the British Dairy Farmers' Association, whose labours were consulted or employed right and left by other associations, and by the County Councils at the time of the establishment of the system of technical education. These men have done their work, and in large part have been succeeded by trained students who are now professionally engaged in the various departments of instruction and investigation.

Modern Dairying. In this country the production of milk for sale in its natural condition has become the most important feature of dairy farming, elaborate machinery as shown in 1 and 2 being employed to-day. The limited size of our islands, with their large population, practically forbids the production of all the butter and cheese we require for our consumption. Thus, while the importation of fresh milk is practically prohibited by time and temperature, the daily demands of the people make it imperative upon the farmer to abandon to a very large extent the manufacture of the two chief products we have named for what in most cases is the more lucrative practice of producing milk for sale. There is, nevertheless, still great scope for the production not only of more milk, but of more butter and cheese, and in each case of better quality. The following figures, which relate to the year 1905, will furnish some idea of the enormity of our import trade, a trade which to a large extent should be in our own hands.

	Quantity		Value
Butter ..	4,147,866	cwt. ..	£21,586,622
Cheese ..	2,442,682	.. ..	6,339,811
Condensed Milk	893,634	.. ..	1,584,363

In addition, we paid 2¾ millions sterling for margarine, the total value in dairy produce amounting to 32¼ millions, or ten millions more than we paid ten years ago.

The Present Position of Dairying. We shall still further enable the reader to understand the present condition of the industry at home, and what it is still possible to accomplish, when we point out that the average consumption of milk is considerably less than half the average consumption of beer, though the average consumption of milk has increased during the past few years.

The products of British dairy farming are:

1. Milk for sale.
2. Cream for sale.
3. Butter.
4. Cheese, which is manufactured in five forms—(*a*) pressed, (*b*) blue veined, (*c*) unpressed, (*d*) soft, (*e*) cream, and
5. Condensed and other forms of preserved milk.

Skimmed milk is also sold in large quantities, but it is known to be largely employed as an adulterant of new milk.

Milk. Milk produced for sale varies in quality. In accordance with the Government standard, it must contain 3 per cent. of fat. The richest milk produced by farmers and others—that from Jersey, Guernsey, and Devon cows—seldom finds its way into the market; it contains from 4½ to 5½ per cent. of fat, individual cows often doing still better, and possesses greater value for butter production than the milk of other cattle.

Cream. Cream is sold in two forms—(1) that which is skimmed by hand or by the separator, and sold quite fresh or in jars, in which it is preserved for keeping by the deleterious admixture of such drugs as boracic acid or formalin, by which practice its flavour is spoiled; and (2) clotted cream, almost exclusively the production of Devon, Cornwall, and Somerset. This material, richer in flavour, having been submitted to heat, keeps under natural conditions much longer than cream skimmed by hand or by the separator.

Butter. The butter we produce varies in quality and character as much as in price, 7d. a pound being by no means uncommon in some markets during summer, while 1s. 6d. and still higher figures are often realised by skilled makers, oftentimes amateurs, as the production of a Jersey or a Guernsey herd. British butter may be divided into two categories, that which

is produced on the farm and that which is the product of the creamery or factory. The average samples of either are, perhaps, not superior to the best brands imported from France and Denmark, but the best brands in this country, such as those exhibited at the National Dairy Show at Islington in October, are incomparably superior to anything we import, or which, as we believe, it is possible to land on these shores in the present state of our knowledge. We are compelled to admit that our inferior brands of farm butter are less palatable than the uniform product of the Danes and the Normans, and it is for this reason that the character and the flavour of our best butter is practically unknown to the average consumer. The best imported butters are the factory brands of Denmark, and the best blended butters are those of France; following these in order come the products of Canada, Italy, Holland, Australasia, Germany, and Russia.

Cheese. Cheese is made in this country in great variety, although to a much less extent than in France. British cheese may be classed as follows:

PRESSED.

Cheddar, Cheshire, Gloucester, Leicester, Derby, Lancashire, Wiltshire Loaf.

BLUE VEINED.

Stilton, Wensleydale, Cotherstone, Dorset (chiefly skimmed milk).

UNPRESSED.

Caerphilly.

SOFT AND CREAM.

Yorkshire Curd, Godmanchester, Colwick, Slipcote, Coulommiers, Gervais, Pont l'Evêque (the three last-named are imitations of French articles), and Cream.

The most important British cheese is Cheddar, which is the type of the product which reaches us in such large quantities from Canada and Australia and the United States. In flavour and character it probably stands at the head of the cheese products of the world, although closely approached by the best Gruyère of France and Switzerland, and the Gouda of Holland. Cheshire of fine quality is largely consumed by the huge manufacturing and operative population of Lancashire, Yorkshire, and Cheshire. Leicester in its finest form is the most mellow of all British pressed varieties, but the art of making the best, if not lost, is now apparently but little practised. Stilton, made by a limited number of farmers, the majority of whom produce an inferior article, is practically on the market only during a limited season from December forwards, although it might and should be produced for sale during the whole year. Its superior quality as compared with the veined cheeses of the Continent, notably Gorgonzola, fits it for a lucrative and extensive export trade, but it is, even in our own country, superseded throughout the entire year by Gorgonzola of second and third rate quality hailing from Italy. Wensleydale, at its best, is equal to the finest Stilton produced. Our curd and cream cheeses are much fewer and infinitely inferior to those produced in France, in which country the soft-cheese industry is of enormous proportions, enabling milk-producing farmers to realise much better prices than are obtained in this country, though the same results are possible. We are content to import Brie, Camembert, Roquefort—a sheep's milk blue-veined cheese—Pommel, a mixture of cream and milk curd; Port du Salut, which somewhat resembles our Caerphilly, although superior in quality, and other varieties, all of which it is possible for our people to produce with great profit to themselves.

Condensed and Preserved Milk. Condensed milk is now manufactured both from the pure and the skimmed milk of the cow, which also produces the raw material from which various brands of dried or powdered milk are manufactured. Beyond the fact that the farmer produces the milk for the manufacturer, the preserved milk industry has practically no relation to dairy farming.

Creameries. For many years the factory and creamery systems have been extending in all dairy farming countries, although in England, perhaps, least of all. The milk is contributed by the farmer, tested on its receipt, skimmed, the cream in most well-conducted establishments

1. WASHING MILK CANS BY STEAM

2. CREAM SEPARATOR CHURNING AND MAKING UP THE BUTTER
(Photographed in one of Messrs. Welford's dairies)

sterilised, inoculated with a prepared starter containing the bacteria necessary for the production of flavour and quality, and subsequently churned in large quantities (2). Next to Denmark, which has led the world in this department of the dairy industry, Ireland is perhaps the most notable example of progress in the creamery system. As we write there are in Ireland 342 creameries on the co-operative system, apart from many others of a private character. Improved work has enabled the Irish, while increasing the price, to increase the yield also.

Value of Bacteria. The introduction of the *cream separator* more than twenty years ago by the Swedes and the Danes was almost contemporaneous with the inauguration of advanced dairying in this country; although followed by other inventions, it effected a practical revolution. Since that time the discovery that the flavour of butter and its keeping qualities are controlled by bacteria has enabled the maker to effect further improvements, so that the product of to-day, while far in advance of that manufactured by the past generation, will keep for a longer period. Much the same transformation has occurred with regard to cheese, which is now manufactured by all competent persons on the basis of scientific teaching.

Progress in one direction, too, has been accompanied by progress in another. The discovery of a method of manufacturing an imitation butter, known as margarine, by the aid of *oleo*, an important production of the Chicago stockyards, has led to its admixture with pure butter, and consequently to a form of adulteration which is now punishable by law, but which in this country is often difficult of detection. Butter, however, which normally contains from 12 to 14 per cent. of moisture, is also adulterated with water up to as much as 25 per cent., although a Bill for the prevention of the fraud, and limiting the water percentage to 16, has been introduced into the House of Commons by the Minister of Agriculture.

Sale and Yield of Milk. It is also instructive to learn that the farmer still sells his milk to the dealer, in spite of the existing law, by the barn gallon of 17 pints, practically 2 gallons with a pint overplus, which in earlier days was regarded as necessary to make up for the loss in retailing. Milk is usually sold under contract, realising a higher price from October to March than during summer, usually 1s. 8d. to 1s. 9d. per barn as against 1s. 4d. to 1s. 5d.

The dairy farmer's success depends almost entirely upon the productive powers of his cattle, and, therefore, upon his own skill as a buyer or breeder, and as a feeder. The average yield of milk in this country, as in America, is about 440 gallons per cow, which is an insufficient quantity to provide a profit. The fact, however, indicates that as there are large numbers of cattle which yield considerably more—from 1,000 to 1,200 gallons in individual cows, and from 600 to 700 gallons over whole herds—numbers of farmers must be owners of cows which yield considerably less than 400 gallons. The dairy farmer is more often than not a breeder of his own stock, and he should mate his cows with a bull of a milking strain, whose influence will assuredly result in the improvement of the milking properties of almost every heifer calf which is born to him. In this country we have no system of testing and recording cows as milkers, consequently we have no milking herd-book, or record, as is the case in the United States. For the same reason, too, a progressive farmer desiring to mate his stock and to breed upon scientific principles for the purpose, has no useful means of ascertaining where to obtain a bull of a known milking strain, or cows which are themselves milkers of the highest type.

Feeding Principles. Economy in milk production may be effected in another direction. There is nothing in the management of a herd so important as a knowledge of the principles of feeding. To rely solely upon the common produce of the farm—hay, straw, and roots—is in these days absolute folly; yet there are many dairy farmers who use neither corn nor cake, or who, making purchases of

both, employ them without recognising the principles upon which they should be selected. This matter has been discussed in the section upon Foods and Feeding in Farming, but it is essential to point out that rich foods are necessary up to a certain point to provide for the manufacture of the solid materials which milk contains; and that those foods might be grown upon the farm in the great majority of instances at very much less cost and with far greater economy than by purchasing them, or their equivalent, in the market [see pages 2702-2706 and 2904-2909].

Improvement in Dairy Production. Our third proposition relates to the exercise of greater skill in the production of butter and cheese. It is possible that less than 10 per cent. of our farm manufacturers of these two products are failing to obtain better prices owing entirely to deficient knowledge. Dairy schools exist, and itinerary instructors travel in many counties at the expense of the ratepayer; nevertheless, large quantities of English farm butter are sold week by week at much lower prices than are realised by imported brands, while the quantities of first-class cheese which are obtainable by dealers are so small, and of second and third class cheese so large, that one is almost inclined to despair of the future of British dairying. Butter which realises 8d. per lb.—a very common price in summer—practically returns, allowing 1½d. a gallon for the skimmed milk, from 4d. to 4½d. per gallon, whereas when 1s. 2d. to 1s. 3d. is realised—and still better prices than these are obtainable for first-class Jersey or Guernsey butter—7d. per gallon may be obtainable. There are two reasons for this, the more perfect removal of the cream from the milk, and greater skill in manufacture. It is precisely the same with cheese. Many makers fail to obtain more than 50s. to 60s. per cwt. Others, equally clever in marketing as in manufacturing, obtain from 75s. to 85s., and in exceptional cases still higher figures, without adding the value of the whey.

Marketing. This question, which brings into prominence the business side of the farm, is one which is very much neglected. The farmer is seldom found circularising the public, or taking any steps by advertisement or otherwise to obtain regular customers with whom he may conduct a weekly retail trade. His cheese is sold to a merchant; his butter, more frequently than not, to a local shopkeeper, who is clever enough to obtain a profit upon what he buys as well as upon what he sells.

Among other subjects that may be briefly discussed here are some which directly bear upon the economy of the dairy. It is the custom in this country to house cattle during the night early in October, but it has been shown by demonstration at the Harper Adams College at Newport, in Shropshire, that where the cows are kept out of doors on the pastures at night to the close of the year instead of bringing them in with October, money is saved. This is one among many questions which farmers should test for themselves, whatever their practice or belief may be. Again, in the rearing of young stock it has been demonstrated by the officers of the Yorkshire College that great saving may be effected by feeding calves upon skimmed or separated milk to which cod-liver oil has been added in order to replace the fat that has been removed in the cream. During successive years groups of calves were reared to maturity, the accounts being strictly kept, on two systems of feeding, with *whole* milk and with *skimmed* milk and oil, and in each case the results were in favour of the latter.

The practice of town cowkeepers, who buy of the best that can be found, is to fatten each animal for the butcher as its milk supply decreases, with the result that there is a continual drain of the best cows in the country, very many of which are of high value as stock for breeding purposes. Whatever may be the practice, the principle is wrong.

Tuberculous Milk. Since the discovery that the disease known as tuberculosis may be communicated to man through the milk which he consumes, great efforts have been made not only to confirm the belief, but to prevent the possibility of an affected cow being retained in any herd or dairy. Many breeders and cowkeepers have, in consequence, submitted their cattle to what is known as the tuberculin test. The injection of the serum known as tuberculin—which contains no living bacilli—is followed by symptoms which, where tuberculosis exists in the slightest form, indicates the fact, and enables the owner to remove her from his herd. There are, however, doubts both in the minds of scientific and practical men as to the efficacy of the test, in spite of the many apparent proofs which have been demonstrated, as well as to the truth of the fact that the germs of the disease are found in milk. Hence we may suspend our judgment in some degree, yet we are bound to express the belief that where the udder of the cow is tuberculous—and this is recognised practically by all public authorities—the milk which is drawn from it is a source of danger to human life.

Continued

THE NOVELISTS OF TO-DAY

Being the Conclusion of English Prose Fiction. A Note on the Present Condition of the Novel Short Studies in Meredith and Hardy. The Test of a Novel

Continued from page 3442

By J. A. HAMMERTON

WE completed with our previous study a rapid yet comprehensive survey of English Prose Fiction as it is embodied in the writings of the more notable novelists of the past down to Robert Louis Stevenson. The extent of the subject, and our desire to maintain throughout the historical method of treatment, left us little or no space to devote to the separate consideration of the great variety of literary forms which might reasonably be included under the head of the Novel, not to say the still greater variety of which the term Prose Fiction admits. But the student anxious to pursue further the studies which we have at least begun will find in what has been set down many finger-posts pointing the way to increased knowledge of the subject, while the general reader will have secured what might be termed a rough ground-plan, or working outline, of all that is best worth reading in English Prose Fiction.

The Good Work of Our Own Day. For the present study we have reserved the work of those novelists who are still living and in most cases still writing, as we are persuaded that there is great need in a work of this kind to insist upon the merits of living writers when so much of our attention must necessarily be drawn to the authors of the past. We have no sympathy with those critics who seem never so happy as when they are sneering at the productions of their contemporaries. A very little study of literary history will show that in all ages there have been critics who have maintained this pose. Shakespeare had many detractors in his own day, Scott was not without his adverse critics, Dickens was scoffed at as a writer of low Cockney books. Rather is it desirable to look around us, that we may discover what is good in the work of our contemporaries. And if we but do this to-day we shall be agreeably surprised to find how excellent is the prose fiction of our living writers.

The Novel a Perfected Instrument. If we have not many giants among us—and this is the most difficult of all things to determine, as we do require some distance of time to measure accurately the real dimensions of a great writer—there is no manner of doubt that the general level of excellence represented by the body of contemporary fiction is considerably higher than that obtaining in any former period of our literary history. The novel has become in our own day a perfected instrument. From a formless, lumpish, uncraftsmanlike thing, such as we find it in the hands of even great writers in the past, it has developed into an admirably proportioned and wonderfully effective literary medium.

What we are saying is that the average good novel of to-day is as superior to the average novel of the mid-Victorian days as a modern express locomotive is superior to the old "Puffing Billy." This means that the literary art, as distinct from genius, which may be, but is not always, above and independent of convention, has vastly improved from the days of our forefathers. Though all this will be held to require considerably more proof than we can possibly hope to advance in this very brief study, we may content ourselves by suggesting that in support of our assertion we have only to examine any representative story by such writers as Mr. Israel Zangwill, Mr. Eden Phillpotts, Sir Arthur Conan Doyle, Mr. Halliwell Sutcliffe, Mr. S. R. Crockett, Mr. R. S. Hichens, Sir Gilbert Parker, Mr. Neil Munro, Mr. A. E. W. Mason, and at least a score of other equally well-known writers, to realise how firm and admirably wrought is the texture of our contemporary fiction as compared with that of any previous period.

A Healthy Sign of the Times. The fact that side by side with what is entirely praiseworthy in the modern novel there exists a vast amount of fiction that is undeniably trashy, false to every canon of the literary art, useless and often worse than useless as furnishing for the mind, has led many hasty critics into unfortunate generalisations condemnatory of the whole body of contemporary fiction. In all times, and everywhere, the weeds have flourished as luxuriantly as the flowers—often more profusely. It is so to-day in the world of letters, but not more so than at any time in the past. That so many of our best living novelists are widely and intelligently read by an ever increasing public is of far more importance than the fact that an immense number of superficial writers secure large circulations for their works by the patronage of the uncultured. While we cannot hope in the little space that remains to us to do justice to the best work of our contemporary novelists, and while many worthy of some attention at the hands of all who would be well versed in living writers may have to be passed over with the mere mention of their names, we may at least do something to preserve a sense of proportion by ignoring entirely many more who have won only the ignorant approval of the mob.

The Two Greatest Novelists. There is, of course, a sense in which the two greatest living novelists, Mr. Meredith and Mr. Hardy, should have come into our previous study. As writers of fiction, both may be said to have ended their careers. It is a pity that it should be so; that Mr. Meredith should have written no work of fiction since 1895, and that

Mr. Hardy, who is not yet seventy years of age, should have laid down the pen of the novelist when he was only fifty-two, with all his brilliant powers at their ripest. But the fact is so, and we must not complain, for each has to his credit a splendid tale of work; and although they are essentially of the Victorian Age, it satisfies our pride no less than it fits in with our historical method to regard them as our contemporaries of to-day.

George Meredith. Stevenson owed a great deal to GEORGE MEREDITH (b. 1828); and this fact may be taken as specially significant. What, we may well ask, adapting a well-known line, do they know of Meredith who only Meredith know? The answer is that they know a great deal, but that the great deal falls very considerably short of the whole. Though his first book, a volume of poems, was published in 1851, Meredith did not begin to be appreciated by the public till quite thirty years later. Even to-day, though there exists what is called a Meredith cult, it cannot be affirmed that its "idol" is popular. We may reasonably doubt if he will ever be read as widely as, say, Thackeray; if he will ever become a "classic." But to the student of contemporary English fiction Meredith is something greater than a popular writer. He is, and has been for years, a great influence. Stevenson counts but as a unit among those who have been and who will be influenced by him. There are various reasons for the power he has exerted over his contemporaries. The chief reason is that he has chosen to look at life with his own eyes, and to describe it in his own words. The life he depicts may not be the life with which we are all familiar. His people are, as he has described them, "actual, yet uncommon." Meredith is a social satirist. Full often he smites and spares not. But it is scalpel work, never mutilation. He was a poet before he was a novelist, a philosopher before he was a poet, and his novels are poetry and philosophy combined. His place is with Browning and Carlyle. They and he have the defects of their qualities. But what splendid qualities these are! Meredith is thought-compelling. He gives exercise to the mind. He is a fellow-traveller on life's journey who gives readily from a store of experience that is vastly greater than our own.

How to Study Meredith. Some of us have not yet learnt that we get no more from a book than we bring to it: minds have to be "worked" as well as mines. The Meredithian mind is an intellectual Golconda. The right way to "work" it is to study the man and find out the origin and motive of his writings. None of Meredith's novels can be fully appreciated at a first reading. Knowledge, as well as industry, is essential. How, for example, can "The Tragic Comedians" be understood unless the reader know something of the career of the German Socialist Lassalle? But the diligent student will find Meredith to a very considerable extent self-critical and self-explanatory. As to his style: this is admittedly difficult; it is like a river with many tortuous windings but noble reaches. But his English, at its best, is the best English of the time. He is to be studied, not imitated; and the study should result in a disregard for the iteration of toil-worn phrases. "A writer," he says, "who is not servile and has insight must coin from his own mint."

Meredith's Style. It has been very happily said of him that "he thinks in metaphor," which is precisely what the ruck of mankind does not do. Hence, it is not surprising that to the average reader the works of this great novelist should present grave difficulties of style. Curiously enough, we find his poetry presenting a clearness and grace of diction, a simple beauty of words, which is nearly always foreign to his prose manner. The late Ashcroft Noble observed with much truth that "his speaking voice is an affair of organisation; his singing voice is the result of careful training." In other words, Meredith the novelist tells his story in a manner natural to the man; but in his poetry the conscious artist, under the restraint of his medium, has to rid himself of the perpetual involutions of metaphorical thought which are natural to him and characterise his work in prose.

Begin with "Richard Feverel." There can be no question that the best of Meredith's novels to begin with is "The Ordeal of Richard Feverel." If we ask "What is education?" we have here an answer equivalent to many debates in Parliament and many speeches on political platforms. We have education not merely described, but seen in action. If we ask "What is love?" "What passion?" we have but to take up "Richard Feverel" to see these two dominating attributes of our common human nature set forth with a freshness, a vigour, a reverence, a sympathy, a feeling for external nature—with a knowledge, in short—unrivalled by any other writer of contemporary fiction. If we seek an example of the analysis of motive we cannot do better than study, and we shall be the better for studying, the dissection of Sir Willoughby Patterne in "The Egoist," in modern fiction surely the most finished portrayal of any type of character, an "uncommon" character in which every reader will find some phase of his own self revealed to him. "Beauchamp's Career," "Diana of the Crossways," and "The Adventures of Harry Richmond" are the best of Mr. Meredith's other novels; "The Shaving of Shagpat" the most richly imaginative. To show that genius, if not always "the art of taking pains," does not despise drudgery, it may be sufficient to mention that for thirty years Mr. Meredith was literary reader to a well-known firm of publishers.

Thomas Hardy. If with Browning and Meredith we believe that

"God's in His heaven
All's right with the world!"

a study of the novels of THOMAS HARDY (b. 1840) will be a somewhat mixed pleasure. Hardy, even more than Meredith, has great dramatic qualities. But Hardy's is the voice of the

countryside—of the countryside that is far removed from town. To him the greenwood tree suggests not merriment, but destiny; a pair of blue eyes not heaven, but Fate. Life is a tragedy with a few interludes. The coast of Dorset might almost be the shores of old Armorica. Yet the philosophy of this Dorset seer is stern, not weeping. The words of religion are quoted freely in his novels, but in the spirit of the educated pagan. The peasants he introduces to us belong to a part of England the exclusiveness of which is only now being broken into. Their ways and modes of thought are depicted with a realism that is pitiless, though the novelist lightens his narratives with many a flash of genuine humour. Hardy is a writer who must be approached with an understanding of his own environment, which is the environment of the characters of his novels. The student must gain the novelist's point of view; then, even in the case of "Jude the Obscure," in place of the repulsion that many might otherwise experience simple admiration of the writer's art will be awakened. This art is undoubtedly circumscribed, but it is great art, nevertheless. Every incident in the novels written by Thomas Hardy is calculated with unerring skill; the movement is controlled from the outset with the deliberation of conscious art. The style is as direct as the plot; its distinction is derived from its subject-matter.

Hardy's Best Novels. With Hardy, style without thought is mere vanity. "A writer's style," he once wrote, "is according to his temperament; and my impression is that if he has anything to say which is of value, and words to say it with, the style will come of itself." Like Meredith, Hardy is a poet; like him, again, he is scarcely a "popular" author, though both have enjoyed in more recent years far more public favour than in the prime of their lives. We have said enough, perhaps, to show that he is an important novelist for the student. His best works appeared in the following order: "Under the Greenwood Tree" (1872), "A Pair of Blue Eyes" (1873), "Far from the Madding Crowd" (1874), "The Return of the Native" (1878), "The Mayor of Casterbridge" (1886), "The Woodlanders" (1886–7), "Tess of the D'Urbervilles" (his greatest novel, 1891), and "Jude the Obscure" (1894-5). The reader would do well to take up his novels in this sequence; but "Far from the Madding Crowd" may be mentioned as thoroughly representative of his art.

The Test of a Novel. At this point, and touching "Far from the Madding Crowd," we think it well to define more particularly than we have yet done the supreme quality of a good novel. We have in our previous study seen that the melodramatic story is one in which incidents are of first importance. Human nature, the facts of life, do not concern writers of this class of fiction. Their chief stock-in-trade is the "thrilling situation." True, in life there are many incidents as thrilling as any ever invented by the most ingenious sensation monger, but the difference lies in the fact that the great episodes of life, like the great rivers of the world, have their source in little things, and convey no lesson to us unless we know something of the source from which they spring. In all works by masters of fiction it will be found that the "supreme moments," the crises which they describe, have grown steadily, remorselessly, fatefully out of the lives of their "dramatis personæ," and have not been invented merely to "thrill" or shock the reader. This does not mean that the supreme moment must come late in the story; it may occur early in the narrative; but when such is the case it will be found to dominate the entire book, to shape and colour everything that follows.

The "Inevitable" Incident. If the reader will turn to "Far from the Madding Crowd," he will find that the fifth chapter contains one of the most tragic episodes in modern fiction, related in a simple, unaffected style, but coming like a peal of near thunder on a summer day, startling, portentous, "thrilling" if you will, but absolutely inevitable in the drama the novelist is unfolding. It tells how Gabriel Oak, the young farmer who is the hero of the story, has come within sight of his long-toiled-for success, and has thoughts of marriage, when, one night, he is reduced to ruin by the misguided zeal of a sheep dog, which drives some two hundred of his flock, whose lambs have not yet come, into a chalk-pit. "The sheep were not insured. All the savings of a frugal life had been dispersed at a blow. . . . It was as remarkable as it was characteristic that the one sentence he uttered was in thankfulness: 'Thank God I am not married! What would she have done in the poverty now coming upon me?'"

This tragic episode is described with perfect literary art and fidelity to life. It keys the whole story through the fifty odd chapters that follow. It exercises a mighty influence on the character of the hero and his relations with the other persons of the romance. It is essential to the story, woven into the web of it, impossible to be removed without ruin to the whole. That is what we mean when we speak of the incidents in the works of great novelists as being "inevitable." When the reader thoroughly appreciates this, he will have no difficulty in distinguishing between the novel of true character and drama and the novel of false character and melodrama.

Kipling and Social Criticism. One of the principal features in the fiction of our time is its note of social criticism, especially in regard to women. Mr. RUDYARD KIPLING (b. 1865), touched this note in "The Light that Failed"; but Kipling is to be found at his best in his short stories of Anglo-Indian life, such as "The Incarnation of Krishna Mulvaney," "The Courting of Dinah Shadd," "The Man Who Was," "Without Benefit of Clergy," "The Drums of the Fore and Aft," and "Georgie Porgie." In his prose as well as in his ballads he has depicted the Cockney soldier abroad with unerring insight and fidelity. His prose fiction is as worthy of serious study as that of any master of the near past. Whether his opinions please or irritate us, we must acknowledge that he possesses an absolute individuality in his

style; that he is a "maker" and not a mere journeyman of letters. The clash of rival forces and the mystic spirit of the dreaming East have found reflection also in the work of Mrs. Flora Annie Steel (b. 1847), particularly in "On the Face of the Waters," and the short stories published under the title of "In the Permanent Way." The bitterness of outlook in the novels of Thomas Hardy is more than equalled in "The Story of an African Farm," written by Mrs. Olive Schreiner when she was quite a girl, and her one book of real literary value; but even this bitterness is excelled by the revolt of "The Gadfly," by Mrs. Voynich. Revolt, too, though of a more temperate kind is a characteristic of the novels—"Marcella," "The History of David Grieve," and "Robert Elsmere"—of Mrs. Humphry Ward (b. 1851), a granddaughter of Arnold of Rugby, and a writer whose work claims consideration with, as it is influenced by, that of George Eliot and Charlotte Bronte. Revolt again, with a more decided accentuation of the sex problem, is reverberant in "The Heavenly Twins," by Mme. Sarah Grand; "The Open Question," by C. E. Raimond (Miss Elizabeth Robins); "Keynotes," by George Egerton (Mrs. Golding Bright); and "The Yellow Aster," by Mrs. Mannington Caffyn—works noteworthy chiefly as representative of a passing phase of thought, rather than of enduring value.

The "Society" Novel. What is called the "society novel" includes among its writers Mr. E. F. Benson (b. 1867), author of "Dodo" and "Mammon & Co."; Mr. F. C. Philips (b. 1849), author of "As in a Looking-glass"; Mr. Percy White, author of "Mr. Bailey-Martin," "The West-End," and "Andria"; "Benjamin Swift" (Mr. William Romaine Paterson) (b. 1871), author of "Nancy Noon" and "Ludus Amoris"; Mr. John A. Steuart (b. 1861), author of "Wine on the Lees"; Mr. William J. Locke (b. 1863), author of "Derelicts"; Mr. Vincent Brown, author of "A Magdalen's Husband"; Mr. Edwin Pugh (b. 1874), author of "Fruit of the Vine"; Mr. Leonard Merrick (b. 1864), author of "The Man Who Was Good," and "The Worldlings"; "Ouida" (Mlle. de la Ramee), author of "Moths" and "The Waters of Edera"; Miss Braddon (Mrs. John Maxwell) (b. 1837), author of "Lady Audley's Secret"; Mr. W. B. Maxwell, a son of the last-mentioned writer, author of "Vivien," "The Ragged Messenger," and "The Guarded Flame," all works of distinction.

Mr. H. G. Wells (b. 1866), in addition to writing a series of remarkable semi-scientific, half-sociological works, which have caused him to be compared to both Jules Verne and Herbert Spencer, has in "Kipps" penned a social satire of exceeding power. Miss Violet Hunt, author of "A Hard Woman," "The Celebrity at Home," and "Sooner or Later," and Miss Beatrice Harraden (b. 1864), author of "Ships that Pass in the Night" and "Hilda Strafford," are writers whose works are representative of the mingled satire and brilliant pessimism which is to be found in the books of many women novelists.

Realists and Others. Among those who have sought, somewhat after the method of the French school, to photograph humble life, may be cited Mr. Arthur Morrison (b. 1863), author of "Tales of Mean Streets"; Mr. George Moore, author of "Esther Waters," and an acknowledged pupil of Zola; William Somerset Maugham (b. 1874), author of "'Liza of Lambeth"; and Mr. Richard Whiteing (b. 1840), author of "No. 5, John Street." In "The Passport," Mr. Richard Bagot (b. 1860) has written a brilliant exposure of Vatican intrigue; and religion and ethical questions are dealt with by Mr. William Hurrell Mallock, Dr. William Barry (b. 1849), Mark Rutherford (Mr. William Hale White), Mr. C. Ranger Gull (b. 1876), and Mr. F. T. Bullen (b. 1857). "Questions of the day" form the theme of such purely "popular" writers as Mr. Hall Caine (b. 1853) and Miss Marie Corelli. Mr. Coulson Kernahan (b. 1858) has achieved distinction in the department of allegory, and allegory may also claim "The Garden of Allah," by Mr. Robert Hichens (b. 1864), who has also written in "The Woman with a Fan," a striking novel of society life, and in "The Black Spaniel" touched the macabre vein, so distinctive of the work of Mr. Arthur Machen (b. 1863), author of "The House of Souls" and "The Great God Pan."

Modern Romance. In the realm of historical romance, prominent places are claimed for Sir Arthur Conan Doyle (b. 1859), author of "The White Company" and "Uncle Bernac," and the creator of "Sherlock Holmes"; Mr. Stanley Weyman (b. 1855), author of "A Gentleman of France," "Under the Red Robe," and "My Lady Rotha"; Sir Gilbert Parker (b. 1862), author of "The Seats of the Mighty"; Mr. Anthony Hope (Hawkins) (b. 1863), author of "The Prisoner of Zenda" and "Quisanté"; Mr. Maurice Hewlett (b. 1861), author of "The Queen's Quair"; Mr. S. Levett-Yeats, author of "The Chevalier d'Auriac" and "Orrain"; Mr. S. R. Crockett (b. 1860), author of "The Red Axe" and "The Raiders"; Mr. Bernard Capes, author of "A Castle in Spain"; "John Oliver Hobbes" (Mrs. Craigie) (b. 1867; d. 1906), whose tragic death occurred as these pages were being passed for press, author of "A School for Saints" and "Robert Orange"; Mr. Ford Maddox Hueffer (b. 1873), author of "The Fifth Queen"; "M. E. Francis" (Mrs. Frances Blundell), author of "Yeoman Fleetwood"; and Mr. F. Frankfort Moore (b. 1855), author of "The Jessamy Bride." Romance pure and simple and fascinating marks almost every book that has come from the pen of Mr. and Mrs. Egerton Castle, joint-authors of "Young April" and "If Youth but Knew." The quality of a rare humour distinguishes the stories of Mr. James Matthew Barrie (b. 1860), stories that stand quite by themselves, as "The Little Minister" and "The Little White Bird," and the short sketches collected in "A Window in Thrums" and "Auld Licht Idylls." The romance of adventure in Far Eastern seas has found in Mr.

Joseph Conrad (joint-author with Mr. F. M. Hueffer of "Romance") a skilful interpreter. Mr. Louis Becke (b. 1848) transports the reader to the islands of the Southern Seas, as in "Rodman, the Boatsteerer"; while Mr. R. B. Cunninghame Graham (b. 1852) has written with masterly touch of the romance of life in South America, as in "The Ipané." Australian life is reflected in the books of "Rolf Boldrewood" (Mr. T. A. Browne) (b. 1826) and Mr. E. W. Hornung (b. 1866), author of "The Rogue's March" and "A Bride from the Bush." Mr. Max Pemberton (b. 1863) has won wide popularity by his novels of pure adventure, a vein also profitably worked by Mr. C. J. Cutcliffe Hyne (b. 1866). South Africa as a field of adventure has been exploited to some purpose in the highly-coloured pages of Mr. H. Rider Haggard (b. 1856), author of "King Solomon's Mines," "She," "Ayesha" (an old title revived), and "Stella Fregelius." The roving spirit is well expressed in the work of Mr. Morley Roberts (b. 1857). Mention must also be made of the fine works of Mr. A. T. Quiller-Couch (b. 1863), author of "Troy Town," "The Splendid Spur," and "The Ship of Stars"; Mr. Theodore Watts-Dunton, author of "Aylwin"; Mr. Charles Marriott (b. 1869), author of "The Column" and "Genevra"; Mr. A. E. W. Mason (b. 1867), author of "The Courtship of Morrice Buckler" and "The Four Feathers"; Mr. John Oxenham, author of "John of Gerisau" and "Barbe of Grand Bayou"; Mr. R. H. Benson, author of "The King's Achievement"; and Mr. W. H. Hudson. There is also much to admire in the writings of the Rev. S. Baring-Gould (b. 1834), whose "Mehalah" has been widely read; Mr. Neil Munro (b. 1864), author of "John Splendid"; Mr. David Storrar Meldrum (b. 1865), author of "The Story of Margrédel"; "Zack" (Miss Gwendoline Keats); David Christie Murray (b. 1847), who has narrowly missed the first rank; Mr. W. E. Norris, author of "Giles Ingilby"; Mr. Alfred Ollivant (b. 1874), author of "Owd Bob" and "Danny"; Mr. Eden Phillpotts (b. 1862), author of "Children of the Mist" and "The Secret Woman"; Mr. Halliwell Sutcliffe (b. 1870), author of "Ricroft of Withens" and "Through Sorrow's Gates," a writer who comes close to Hardy in every respect except that of humour; Mr. W. C. Clark Russell (b. 1844), author of "The Wreck of the Grosvenor"; Mr. Robert Barr (b. 1850), author of "The Countess Tekla"; Mr. Laurence Housman (b. 1867), author of "An Englishwoman's Love Letters" and "A Modern Antæus;" Mr. Israel Zangwill (b. 1864), author of "Children of the Ghetto"; and Mr. Louis Zangwill (b. 1869).

Humour has admirable representatives in "F. Anstey" (Mr. F. A. Guthrie), Mr. W. W. Jacobs (b. 1863), Mr. Barry Pain, and Mr. W. Pett Ridge. Mention must also be made of the success of Mr. Joseph Hatton (b. 1840); while Mr. Jerome K. Jerome (b. 1859) has proved himself a novelist of great power and insight.

Some Prominent Women Novelists. "Lucas Malet" (Mrs. Mary St. Leger Harrison) in "The History of Sir Richard Calmady" made a reputation for power at the expense of more admirable qualities, but the book will not readily be forgotten. Other prominent women writers are Miss Rhoda Broughton (b. 1840), author of "Cometh up as a Flower"; Mrs. Katharine Tynan Hinkson (b. 1861); Miss Jane Barlow, author of "Irish Idylls"; Miss M. Betham-Edwards, author of "Dr. Jacob"; Miss Mary Cholmondely, author of "Red Pottage"; Miss Una L. Silberrad (b. 1872), author of "The Wedding of the Lady of Lovell"; Miss May Sinclair, author of "Divine Fire"; "Maxwell Gray" (Miss M. G. Tuttiett), author of "The Silence of Dean Maitland"; Miss E. T. Fowler (Mrs. A. L. Felkin), author of "Concerning Isabel Carnaby"; "Sidney C. Grier" (Miss Gregg) (b. 1868), author of "Like Another Helen"; Mrs. W. K. Clifford; "Rita" (Mrs. W. Desmond Humphreys); Mrs. L. B. Walford (b. 1845), author of "The Mischief of Monica"; Miss Helen Mathers (b. 1853), author of "Comin' Through the Rye"; Mrs. Katharine S. Macquoid; Mrs. Campbell-Praed (b. 1852), and Mrs. Thurston, author of "John Chilcote, M.P."

The Literary Life. With this very brief glance at the more noteworthy novelists of the day, each of whom has written at least one, and many of them several books well worth reading, we have arrived at the end of our study of English prose fiction, and, indeed, within sight of the end of this course in English Literature, for what is to follow is merely in the shape of appendices, in which we shall endeavour to give in the briefest outline some courses of reading in classical, foreign, and American literature. Most of the other courses in the Self-Educator are concerned with the direct application of knowledge to the daily conduct of life and business. This course in Literature has been designed chiefly for the general reader, that it might aid him to the intelligent study of our great writers and those writers who, though falling short of greatness, have still something to tell that will add in some measure to his intellectual enjoyment. The career of the professional man of letters is in some ways the noblest and the most attractive of all, but the way to it lies through much tribulation, and is not lightly to be entered upon, unless the aspirant has as clear a "call" for the work as the candidate for the pulpit is supposed to have. We have made it no part of our business to indicate to the literary aspirant what his course of action should be, but in the course on Journalism, which immediately follows that on Literature, the aspirant will find how the door may be opened that leads to success in literature. For it is worthy of note that by far the largest number of authors whose names are familiar to the reading public have made their way to reputations in literature by entering the world of letters through the humbler but more easily opened door of journalism.

Continued

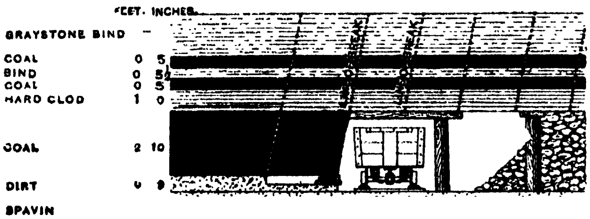
Continued from page 3162

THE WORKING OF COAL

Underground Roads. Different Methods of Dislodging and Removing Coal from its Bed. Machines in Modern Coal Mining Practice

By D. A. LOUIS

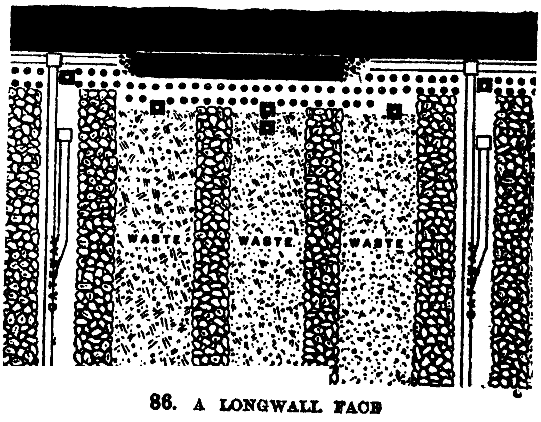
THE first point to consider is the support of the shaft and the building and machinery on the surface, for whatever is taken out below will leave a space into which the roof will sink, and so in succession all the overlying strata, and presently the surface; moreover, should the shaft come within the sphere of influence all sorts of trouble would ensue. Therefore, a block of mineral around the shafts is left intact, except for the roads driven through it. It is known as the *shaft pillar*, indicated at the bottom of 88 and 90 and at the top of 89. It is usually rectangular, with the sides measuring from two-thirds to the whole depth of the shaft; thin seams require smaller shaft pillars than thicker ones, and shallow seams less support than deeper ones. When once the extent of the shaft pillar is decided, the method of working is the next question that arises, whether *longwall* or *pillar and stall* methods will be employed.



85. A COAL-FACE, WITH TUB, PROPS, AND GOAF

Longwall Working. The longwall is the simpler method, and, conditions being favourable, is usually adopted. Galleries to form the main roads are driven in pairs for the sake of ventilation. One road serves for the fresh air to travel along, and is known as the *intake air-way*, while the other serves for the air that has traversed the mine to reach the upcast shaft, and is known as the *return air-way*. When these roads have passed through the shaft pillar—and *longwall advancing* is the method of working followed—the extraction of the coal may commence at once. A passage-way is cut in the coal, right and left from the main roads, the coal being loaded in the tubs and taken away, while timber posts or *props*, and sometimes chocks as well—the small squares on figure 86 indicate chocks—are inserted to support the roof. The tramlines are laid along this passage, so that the tubs or little waggons can be brought right up to the exposed surface of coal, called the *face*. An arrangement at a longwall face is shown in elevation in 85 and in plan in 86.

The coal is then cut away in slices. To do this, the miners *hole* or *undercut* the coal—that is, make a long, narrow cut in a convenient position—with picks, all along the face, supporting it as the cut deepens by short props called *sprags;* and frequently the coal is further supported by a horizontal timber held in position by a prop below, and another jammed against the roof; it is known as a *coker meg*. Undercutting by hand is illustrated in 87, and shows the method of cutting in the middle of a seam. When the cut is sufficiently deep, and taken far enough along the face, a vertical cut is made, *nicking*, to loosen the undercut coal from the adjoining mass; then the sprags are withdrawn, and if the coal does not fall down of its own account, it is brought down by wedging or blasting. The coal is loaded into the tubs and trammed away, and another row of props is put up between the first row and the new face. Any waste brought down with the coal is packed up behind the miners, in the space from which the coal has been removed, making rough sorts of walls, which support the roof to some extent. This waste area is known as the *gob* or *goaf*, and the piles of rock as *goaf packs*. Two rows of props are always kept behind the miner, but when the third row of props is put in, the hindermost props are drawn out and used again; the roof then sinks on the goaf packs. So the order of operations at the face is undercutting, spragging, nicking, withdrawing sprags, bringing down coal, loading it up, tramming it away, building up packs, setting up fresh props, advancing tramlines to new face, and withdrawing back props. In course of time the roof falls and loosely fills the goaf. Special



86. A LONGWALL FACE

precautions have to be observed when drawing props.

Underground Roads. It is obviously useless to attempt to work a long face of coal with only one connection with the main road, as the back waggons would always be delayed by those in front, and *vice versâ*; therefore, the face is divided into convenient lengths called *stalls*, each stall being served by a road called a *stall road*, which is kept open in the goaf by means of walls built of the rubbish, called *pack walls* or *packs*, and those stall roads run into other roads known as *levels* or *gates*, branching obliquely from each side of the main road; they should not, however, start opposite each other. The levels are also made in the goaf. All roads in the goaf are troublesome to keep open; therefore, as the face advances, new levels are started to intersect the stall roads, so that the latter are kept as short as possible, inasmuch as that portion of each stall road behind the new level is abandoned, and consequently ceases to require attention. For the same reason, systems of intermediate roads are frequently introduced to shorten the gates or levels. In the diagram of an actual longwall working shown [88] the gates and levels are taken right to the coal face. The continuous lines show the roads still in use; the dotted lines, those abandoned in the goaf.

87. HAND HOLING IN THE MIDDLE OF A FACE (Photo by H. W. Hughes, Dudley)

The direction that is given to the face is determined by convenience or by selection, and where the cleavage or cleat of the coal is strongly marked, the coal is worked more easily with the face running parallel to the cleavage planes, or, as it is called, *on bord*; but more coal in large pieces, or *round coal*, is obtained where the coal advances at right angles to the cleat, or *on end*. When the coal is worked at an angle of 45 deg, that is, between *on bord* and *on end*—it is said to be worked *on the cross*. The most expedient practice should be adopted, hence it happens that the longwall face is by no means always a long continuous face, but various kinds of sectional or stepped faces are introduced to meet special conditions. The step face in an inclined seam really resembles stope in vein mining.

Longwall Retreating. Longwall retreating is another modification of longwall. In this practice, main roads and gates are driven to the boundary, and the coal is worked back to the shaft. In this way the goaf is left behind, and no roads have to be maintained in it. Fig. 89 illustrates this method of working. The main roads are driven to the boundary of a panel, then two sets of headings, AA, BB, are cut, and then the connecting roads; ultimately the remaining coal is worked back in stepped faces, as indicated; the shading shows the part already worked out.

It will be observed that in longwall retreating the mass of coal is really divided up into solid blocks, with roadways separating them, and approaches slightly to the next method of working coal to be considered.

Pillar and Stall. The method known as *pillar and stall*, *post and stall*, *bord and pillar*, or *stoop and room*, as it is called in Scotland, is adopted when the conditions are not suitable for longwall working. In it the coal is removed in two stages, the first stage known as *working in the whole*, and the second stage as *working in the broken*. In the first stage, the coal is divided into rectangular blocks, or *pillars*, by roads driven at right angles to each other, but leaving sufficient coal on each side to protect the main roads. The roads driven parallel to the cleavage of the coal are known as *walls*, and those driven at right angles to this cleavage as *bords*. The bords are driven 4 yd. or 5 yd. wide, and the walls 2 yd. to 5 yd. wide, while pillars 40 yd., 50 yd., 60 yd., and more square are left, or sometimes the bord side is made longer than the wall side. The roof is allowed to fall in those vacated spaces. Some 30 to 35 per cent. of the coal is taken in the *whole* working. Small pillars are undesirable, because they themselves may get crushed if roof and floor are hard; whereas, if the floor be soft, such pillars press in the floor and cause it to work up in the bords and workings, producing what is called *creep*, which dislocates all arrangements. Fig. 90 is a diagram of one form of this method of working. The diagonal lines indicate the worked-out portion and pillars partially robbed, as the case may be.

Working in the Broken. *Working in the broken or robbing the pillars* is the operation of the removal of the coal left as pillars by the working in the whole, and this is

periods of brisk trade can be more readily responded to.

The features to be desired in a coal-cutting machine are: strength of structure and working parts, durability, convenience of operation, protection of working parts, sufficiency of bearing surfaces, freedom of access to working parts, amount of small coal produced, adaptability to different conditions, simplicity of cutter picks and convenience of changing them, the amount of dust and noise made in working, interchangeability of parts, and amount of power required to operate. And almost every machine invented claims advantages in these and other desirable respects.

The object to be achieved is, of course, to cut a horizontal groove of adequate depth, from 2 ft. 9 in. to 7 ft. according to circumstances, in or beneath the coal. This is done by means of cutters which are brought into contact with the coal or rock and are made to travel with sufficient speed to abraid the coal and so to cut the groove. For this purpose the cutters are set in various fashions in different machines, for instance, round the rim of a wheel, making a sort of circular saw; in the links of a chain, making a sort of band saw; or spirally on a bar. Then two machines of the rock-drill class are also used for holing. There are a few mechanical points that are common to all types. For instance, they comprise engines usually worked by compressed air or electricity, with gearing to set the cutters in motion. They are mounted on skids, or rollers, or flanged wheels running on rails, and most of them are provided with an adjustable hauling arrangement by which they can pull themselves along the front of the coal face at any rate required.

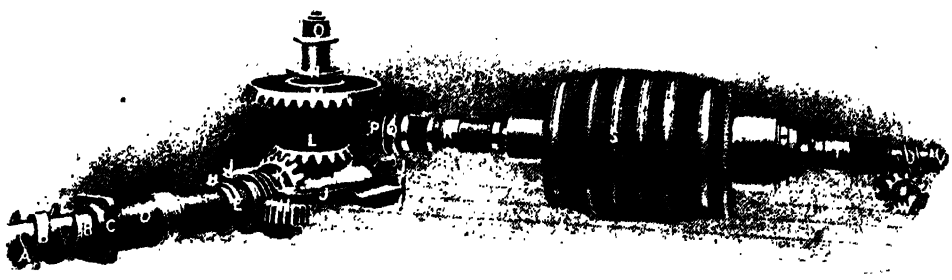
The illustrations [91 and 92] will convey a very good notion of the working of a *disc coal-cutting machine.* The former figure shows the cutter just entering the coal face, and the latter shows the fallen block of coal which has come away very clearly. The arrangement for moving the machine along the face consists of a light steel rope passing from a drum on the machine round a pulley attached to a prop, set in advance, and thence back to the machine, so that, as the rope is wound on the machine by means of gear turning the drum, the machine itself is pulled along

93. SINGLE CUTTER

In chain coal cutters, a travelling chain carrying cutters replaces the disc, otherwise the cut made is similar. With bar cutters, however, the action is different, and 94 shows the working parts of an electrically driven bar coal cutter. Fig. 93 a single cutter.

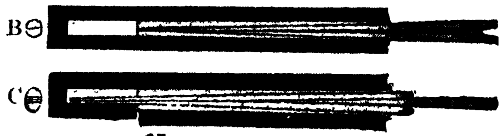
The Pick-Quick Electric Coal Cutter [94] consists essentially of five parts: the *cutter-bar* (A B), the *gear head* (LMNO), the *motor* (S), the *switch box* (T), and *hauling gear* (WX).

The *cutter bar* is of nickel steel and tapered, and is provided with cutters [A] arranged spirally and a spiral thread [B] to act as a worm conveyor for bringing out the cutting. The *gear head* encloses the main gearing, which consists of a pinion on the mortar shaft which drives a double bevel wheel, which, in turn, drives the cutter bar pinion, with a reduction of 2 to 1. The *motor* may be either direct current or alternating current, and the *switches* and resistance are enclosed in a flame-tight cast-iron box. The *haulage gear* is also worked from the motor, and the rate is adjustable. The machine can be adjusted to hole at any height from floor level upwards, and can be mounted on track wheels, flat tread wheels, or skids, and can be *flitted* or work its way back. There are, also, compressed air bar cutters.



94. WORKING PARTS OF ELECTRICALLY-DRIVEN BAR COAL-CUTTER

Dislodging Mineral without Explosives. At times, explosives are inadmissible or inexpedient; hence, various other means have been introduced to get the stubborn holed mineral in which boreholes have been made. Cartridges made of lime have been used. Several of them are placed in the hole, and are then treated with water; they expand, and so force down the coal; but these only act in certain classes of coal. By far the most frequent substitutes for explosives, however, are wedges of different kinds—wedges with feathers, wedges



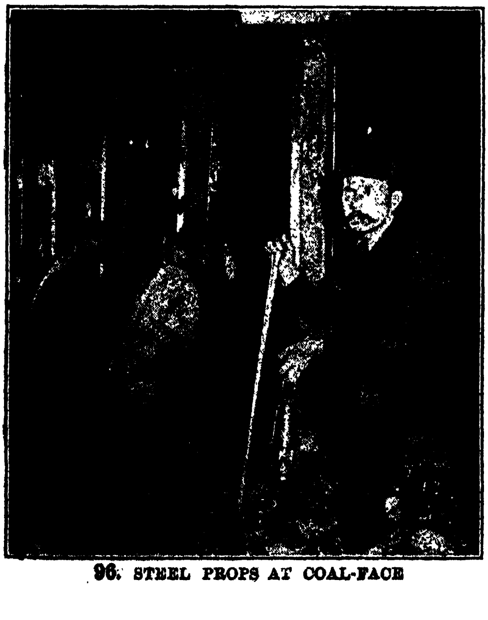
95. MULTIPLE WEDGE

97. ELECTRIC LOCOMOTIVE WITH LOAD

with roller bearings and feathers, hydraulic wedges and multiple wedges are examples. In the case of the multiple wedge [95] the feathers are first placed in position, the split-wedge is driven between them as shown (B), and if necessary a third wedge is driven between the halves of the split-wedge; C shows this and the effect on the surrounding coal.

Conveyers at the Coal Face. With the advent of the cutter, occasion has arisen to expedite the removal of the fallen stuff from the face to the main roads, and recently conveyers have been introduced for the purpose. They are erected on movable supports along the whole length of the face; the coal is easily loaded on to them, and is at once run away to be deposited into tubs waiting at the end of the conveyer, thus obviating the toilsome functions of the putter or the man who manipulates the tubs at the face. The conveyer is easily kept up to the face.

Improved Timbering. In various figures it has been shown, or it has been mentioned, that timber props, timber bars, and timber chocks or cogs are very generally used to support the roof in coal mines much in the same way as in metal mines. But it will be seen that the traffic is considerably greater in coal mines than in metal mines, and the main roads are generally correspondingly larger; moreover, many roads in coal mines have to be maintained in ground filled only with rubbish. Now, any disturbance of a main road means dislocation of the whole area concerned, which is very serious nowadays, when work must be done expeditiously to be remunerative; moreover, one of the most fertile sources of accidents injurious to the men is the falling of the roof. Hence it has become customary in many collieries to replace timber supports by steel ones. We have already referred to such substitution in the case of metal mining, and now show an application of this improvement to coal mining. Various practices have been introduced; the one now illustrated is that followed by Messrs. William Firth, Ltd., of Leeds. Fig. 96 shows steel props set at a coal face with wooden caps. These props are made from ordinary steel girders of section by cutting a piece out of the web at each end and turning over the top and bottom flanges until they meet and make a flat top and bottom that will not cut into the roof or floor or lid. Steel girders are frequently used in a coal mine road; they are not only stronger than timber bars, but they bend under great pressure, and so give warning of the settlement of the roof. Then when bent they can be used again with the convexity upwards or else be straightened and used again.

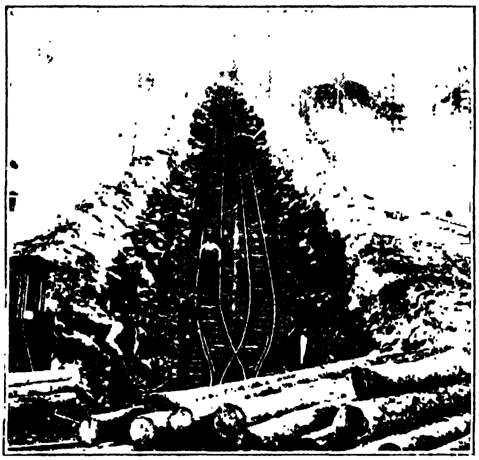


96. STEEL PROPS AT COAL-FACE

Special Timbering. A word may be said here, which would also apply to vein mining, in reference to driving through loose ground, by what is known as *spilling* or *spiling*, and which consists in supporting the weak parts, roof, sides, or floor by driving poles or boards over the last set of timber, 5 ft. or 6 ft. in advance, and supporting them by a temporary set of timber until they are far enough advanced to permit of fixing a permanent set, the ground being excavated the while to facilitate the passage of the boards. We shall now turn our attention to the means employed for getting the broken material from the place where it is deposited to the place where it is required.

Transport Underground. We have seen that in metal mines the usual practice is to run the broken material in single tram waggonloads by hand to the shaft, and the same practice is in vogue for conveying tubs of coal from the face to the nearest main road. But on these latter roads the tubs travel in trains, and either horse or mechanical haulage is employed. This is also done in many metal mines when the galleries are very long or when the waggons are run in trains. The use of ponies was formerly the general method; and such practice is still much followed. When, however, power is available, locomotives driven by compressed air or electricity may be found hauling trains of tubs in many mines the world over. Fig. **97** shows this mode of transport. But in most collieries traction of a less intermittent character is preferred; that is, an arrangement that can be always available to take in the tubs just as quickly as they are brought along from the face.

Self-acting Incline. A favourite method, when the material has to be brought from a higher to a lower level—one, too, that is equally applicable above ground—is the self-acting incline. In this practice the load tubs in their forward progress are caused to haul up the empty ones on their way to the working face to be refilled. And this is effected by having a wheel or drum fixed at the top of the incline round which a rope passes. To one end of this rope the full tub, or train of tubs, is attached, and to the other end the empties. The wheel is provided with a brake, so as to control the speed, and the incline is best made steep at the top and flat at the bottom, to enable the load to start quickly and to be easily stopped. Fig. **98** is a view of the self-acting incline above ground.



98. SELF-ACTING INCLINE FOR BRINGING ORE DOWN TO A STATION

Single-rope Haulage. When, however, the material has to be drawn up an incline, what is known as *single-rope haulage* may be employed. A drum and engine are provided at the head of the incline; the former is furnished with a good brake, and can be thrown out of gear with the engine. This takes place when a train of empty tubs is lowered, for they are run down on the brake, and take the rope with them. When they reach the bottom, the rope is changed from the empty to the full train, the drum thrown into gear, the engines started, and the full tubs are hauled to the upper level when required.

Main-and-tail Rope Haulage. When, however, the levels of the road are irregular, or the incline is not steep enough for the empty tubs to run in-bye and draw the rope with them, then what is known as *main-and-tail rope haulage* is often adopted. There are two ropes. The heavier, or *main rope*, is the full length of the *engine plane* or road, and, passing from the engine, is attached to the front of the full train, and hauls it to the pit bottom; it is then transferred to the rear of the empty train, and follows it in-bye. The lighter, or *tail rope*, is twice the length of the engine plane, and passes round a pulley at the in-bye end. It is attached to the front of the empty train on the in-bye journey, and to the rear of the full train on the out-bye trip. The haulage engine in this case has a drum for each rope, either of which can be thrown in or out of gear as required, and each is provided with its own brake.

Endless Rope Haulage. In this system an endless rope extends from one end of the road to the other, passing round a return wheel at the in-bye end. The rope is kept travelling slowly by an engine placed at the surface or underground; in the former case the ropes are taken down the shaft. The tubs are hung to the rope either singly or in sets, and the rope may travel above or below them. There are many ways of attaching the tubs to the rope. A common and simple means in *over-haulage* is known as the *S-clip*. It is a clamp of round iron, bent to a double U, and pivoted at the centre of the tub. It grips the rope a short distance away along a line which is not over the centre of the track; hence, there is a slight side pull, and sufficient grip to move the tub along without doing the rope much harm. Lashing chains may also be used in this case, but in *under-haulage* a clip must be used to grip the rope, and Fisher's clip is an example of such an applicance. It consists of a hook, which is hung to the draw-bar of the tub, and hinged jaws, with a recess, to hold the rope; a sliding collar serves to lock the jaws, and the tub is released by knocking up this collar. Endless rope haulage requires in addition, driving pulleys, tightening pulleys, or other means of taking up slack; guiding pulleys and rollers; frequently, too, automatic detachers are introduced for releasing the tubs at the end of the journey. In some few cases an endless chain is used for haulage.

Continued

TABULAR BOOKS & BANKRUPTCY

Hotel Books. Visitors' Ledger. Gas Company's Rental Ledger. Bankruptcy. Statement of Affairs. Deficiency Account. Compositions. Proofs of Debt

Continued from page 3420

By J. F. G. PRICE

THE student has already been introduced to the subject of tabular bookkeeping, although it has not hitherto been referred to by that name. Specimens of books kept on the tabular system were given in the petty cash book on page 403, the three-column cash book on page 779, and the columnar purchases book shown in the previous article. The leading principle which those books were designed to illustrate is that items of a similar nature are capable of classification in the books of first entry, and that such classification has the effect of shortening the work of making the final entries in the ledgers of the concern. The principle is capable of considerable expansion in many directions in various businesses and institutions.

Tabular Cash Book. Dealing with the cash book first, it may be pointed out that this is the most important book in such institutions as charities and hospitals where, if a suitable form of cash book is prepared and the book carefully kept, there is frequently no need for any further financial record, as it is a simple matter to prepare a summary of the cash book at any time, showing the position of the institution. As no trading is carried on, no profit and loss account is necessary, the principal account required by, and submitted to, the board of management being an account of receipts and payments, with a statement of outstanding liabilities to date. The latter can easily be prepared from the file of unpaid accounts, and if that is kept up to date the combined cash summary and liabilities statement should be all that is required.

The reason that the tabular system is so suitable for these institutions is that all their receipts and payments fall under a few well-defined heads. For instance, the receipts of a hospital consist of subscriptions, donations, patients' payments, legacies, and income from investments and properties. Many of them also receive grants from King Edward's Hospital Fund and from the Hospital Sunday and Saturday Funds. The receipts side of the cash book might therefore be ruled with columns providing for each of these classes of income, further columns being added for items of miscellaneous receipts and for the total. The payments will consist of the salaries and wages of the medical, nursing, and clerical staff, rent, rates and taxes, tradesmen's accounts, drugs and appliances, repairs, and miscellaneous expenses. Columns would be provided for each head of expenditure and for the total.

Advantage of Classification. In the case of the large London hospitals, such a book as this would, of course, not be sufficient to record all the financial transactions; but even in their cases, such a cash book is of the utmost value in curtailing the clerical work, inasmuch as it classifies the items, and enables the postings to the general ledger to be made in total monthly. The accounts to which the receipts are posted are not, of course, the personal accounts of the donors, subscribers, etc., but nominal accounts for subscriptions, donations, or as the case may be.

In trading concerns, besides the three usual columns for discount, cash, and bank, it is very useful to have on the debit side a column for recording all receipts in respect of cash sales; and on the credit side, a similar column for cash purchases, as the necessity for posting such items in detail to the purchases and sales accounts is thereby obviated, all that is required being that the totals of the columns should be posted at the end of each week or other suitable period. Further, in dealing with the system of self-balancing ledgers, we saw that unless separate cash books were kept for each ledger, columns were necessary on each side of the cash book to record receipts and payments relating to accounts in the respective ledgers. The student, therefore, perhaps unconsciously, has gradually been becoming acquainted with the tabular system in relation to the cash book. A form of tabular purchases and sales book was shown and explained in detail in the previous article, and need not consequently be further dealt with now.

Tabular Ledgers. This brings us to the subject of tabular ledgers, the method of using which may not at once be apparent to the reader. Probably the greatest use of such a ledger in trading concerns is made in hotels where, in large establishments, there would be thousands of personal accounts in the course of a year. The charges to visitors consist of items of the same kind day after day, and it would manifestly be impracticable to have ledger accounts for the visitors on the usual lines, debiting them daily, and crediting the various accounts of the articles supplied, such as apartments, provisions, wines, etc. The staff required to keep books on such principles in a large hotel would be almost equal to that required to run the concern, and would not even then be such as to satisfy the requirements of the proprietor. To meet this difficulty, a form of book has been devised known as *the Visitors' Ledger*, which saves a considerable amount of labour, and yet gives all the information required for the general accounts of the business. An abridged form of such a ledger is shown on the next page. The entries in it are made either direct from slips supplied by waiters and other servants of the hotel, showing the charges to be made against each visitor, or from a day book in which the slips have first been recorded.

MONDAY, 1st JULY, 1905

		Hotel.						Sustentation.						Stock.											
No. of Room.	Name.	Apartments.	Attendance.	Fires and Light.	Baths.	Laundry.	Paid Out.	Breakfasts.	Luncheons.	Dinners.	Teas and Coffee.	Suppers.	Servants' Board.	Wines.	Spirits.	Beer and Minerals.	Cigars.	Totals for Day.	Balance Brought Forward.	Grand Totals.	Amounts Paid.	Discounts and Allowances.	Accounts Carried to Ledger.	Balance Carried Forward.	No.
1	T. White ..	15 0	2 0		1 6	2 0		2 0	2 6	3 6				3 0			1 6	1 13 0	2 4 6	3 17 6				3 17 6	1
2	F. Black ..	5 0	2 0		1 0		1 6	1 6	2 6	3 6					1 6	6		19 0	1 3 0	2 2 0	2 2 0				2
3	W. Green ..	5 0	2 0	6				2 0		4 6	1 6		8 0	5 0				1 8 6		1 8 6				1 8 6	3
4	G. Grey ..	10 0	2 0		1 0			2 6	3 0			4 0		4 6			2 0	1 9 0		1 9 0				1 9 0	4
5	S. Brown ..	7 6	2 0		1 6	4 0		2 0	2 6									19 6	3 6 6	4 6 0	4 5 0	1 0			5
6	J. Pink ..	5 0	1 0							3 6				2 6			1 0	13 0		13 0				13 0	6
7	W. Scarlett	7 6	2 0		1 0				3 0			3 6		3 0	1 0	6		1 1 6		1 1 6				1 1 6	7
8	B. Gold ..	8 0	1 0					2 0										11 0	3 1 0	3 12 0			3 12 0		8
	Total ..	3 3 0	14 0	6	6 0	6 0	1 6	12 0	13 6	15 0	1 6	7 6	8 0	18 0	2 6	1 0	4 6	8 14 6	9 15 0	18 9 6	6 7 0	1 0	3 12 0	8 9 6	

The entries in this ledger require little further explanation than they furnish in themselves. A page of the book, or more, if necessary, is set apart for each day. The charges against each visitor are entered in the manner already mentioned, and cross-cast into the daily total column. Any amount brought forward from the previous day is added, and the total entered in the grand total column. If the visitor pays his account, the amount is entered in the column provided for the purpose, and the account thereby closed. If he does not pay, the amount is entered in the carried forward column, and will appear on the page for the following day in the brought forward column. Any overcharge or other allowance to which the visitor may be entitled, is entered in the appropriate column, and should any visitor leave without paying his account, or if, for any reason, any amount is left unpaid after a visitor has given up his room, the balance due from him is carried into an ordinary ledger, where an account is opened in his name, on which he is debited with the amount he owes.

Connection with General Books. The totals of the first sixteen money columns are entered daily in a summary ruled with corresponding columns, and at the end of a month a journal entry is made debiting *Visitors' Account* in the general ledger with the grand total, and crediting the various nominal accounts with their respective totals for the month. The visitors' account would then be credited with the cash received, and allowances made, and the balance of the account would represent the sum then due from visitors, and should correspond with the amount carried forward in the visitors' ledger on the last day of the month.

Before the totals are entered in the summary daily, care must, of course, be taken that the cross-cast agrees with the sum of the daily total column; and any discrepancy be rectified before the transfer is made. The daily total, plus the amount brought forward, must agree with the grand totals column, which, in turn, must equal the sum of the last four columns in the ledger. The "amounts paid" column should be carefully checked with the "visitors' cash" column on the debit side of the general cash book.

Visitors' Accounts. The accounts rendered to visitors are prepared on the same principle as the ledger, the only difference being that the form is ruled to cover a week. Columns are provided for each day, and for the total, while the different items of charge are shown one under the other instead of as headings of columns. The great advantage of rendering bills on this system is that they can be compiled day by day, and will be ready at any time a visitor calls for his account upon leaving.

The tabular ledger we have been considering owes its form largely to the necessity of carefully analysing the debits to the visitors, in order to ascertain the revenue under the different heads over which the income of an hotel business is

spread. But there is another class of undertaking in which tabular ledgers are not less valuable, where the income is derived from practically only one source, but where there are many debtors with whom transactions take place only at regular intervals and then at some distance of time. Examples of such undertakings are gas, water, and electric light companies. This form of ledger is suitable also for the rate-collecting department of municipal authorities, and for the rent-collecting department of a large estate. The form reproduced on this page is ruled in a manner specially suitable for a gas company, but it will be apparent to the reader that it is capable of being adapted to the requirements of any of the businesses mentioned, and, indeed, to many others.

works, and is intended, as much for the protection of the debtor as of the creditor. The term bankrupt is generally applied rather loosely to any person in a state of commercial insolvency; but, strictly, it should be used only in reference to a person who has been adjudicated bankrupt by the Court. This statement necessitates an explanation of the steps which must be taken before the stage of adjudication can be arrived at.

The first step in bankruptcy proceedings is the presenting of a petition to the Court by a creditor or creditors for at least £50, asking that an order, known as a *Receiving Order* be made against a debtor. Every petition must be based upon what is known as an act of bankruptcy. There are several of

NEW STREET

	Name and No. in Street.	Gas Consumed Quarter to Lady Day.	Rate per 1,000 Feet.	Amount.	Meter. No.	Meter. Rent.	Stove. No.	Stove. Rent.	Arrears.	Total Amount Due.	Paid. C.B. fo.	Paid. Amount.	Bad Debts.	Arrears Forward.	Like Particulars for Midsummer Quarter.	Do. for Michaelmas.	Do. for Christmas.
1	W. Smith	15,600	2/6	1 19 0	657	2 0			2 1 0	4 2 0	68	4 2 0					

This form practically speaks for itself, and very few words are necessary to elucidate it. The amounts due for gas consumed are obtained from the books of the men employed as meter readers, who make a quarterly inspection of the meters for the purpose of obtaining the particulars. The meter and other rents follow a fixed scale. Any charges other than those of a standing character, are not dealt with in this ledger, but are treated separately, and applications for amounts due for fittings, connections, etc., will be dealt with by another department.

Bad Debts Ledger. Any debts regarded as bad, although entered in the column for that purpose, are not thereby abandoned or neglected. The accounts are closed so far as this particular ledger is concerned, but they are transferred to a *Bad Debts Ledger*, which is also kept in a tabular form, and gives brief particulars of the nature, amount, and age of the debt. It is convenient in many businesses to keep such a ledger, for while a trader does not wish to encumber his ordinary ledger with accounts which may be regarded as dead—although there are balances due on them—he does not wish to lose sight of them. They are, therefore, transferred to a book which is largely in the nature of a register, in which only one line is devoted to each. They are thus in a form capable of easy supervision, and although not regarded as assets from the accounts point of view, they may, with careful watching and nursing, result in something being ultimately recovered.

The law of bankruptcy, as it exists to-day under the Bankruptcy Acts of 1883 and 1890, these, and they consist of acts indicating either insolvency or an intention on the part of the debtor to defeat or delay his creditors by more or less fraudulent means. The act of bankruptcy upon which the majority of petitions are presented is known as failure to comply with the terms of a bankruptcy notice. This is a notice served upon a debtor by a creditor who has obtained judgment, requiring payment or security to the satisfaction of the creditor within seven days. If the terms of the notice are not complied with the debtor has committed an act of bankruptcy upon which a petition can be founded. Bankruptcy business is dealt with by a particular division of the High Court, and also by certain of the County Courts, and upon presentation of a petition a day is appointed to hear it. If the court is satisfied that it is equitable that a receiving order should be made it directs accordingly.

The immediate effect of a receiving order is that possession of the debtor's property is taken by an officer of the Board of Trade, known as the Official Receiver, and it becomes the duty of the debtor to lodge within seven days a statement of his affairs.

Statement of Affairs. The statement must be in a form prescribed by the Board of Trade in accordance with the Bankruptcy Acts, and it is in connection with this statement that we are now principally concerned. Several schedules are provided in which have to be entered (1) the different classes of creditors in three groups, (*a*) those

holding no security, (*b*) those holding security to the full amount of their claims, (*c*) those holding security for less than their claims; (2) liabilities of the debtor on bills which he has received from customers and others and subsequently discounted, and upon which he is, therefore, contingently liable as endorser; (3) other contingent liabilities; (4) claims of the landlord for rent, which he can recover by distress; (5) claims for rates, taxes, wages, etc., by creditors who are given a special priority over others against the general assets not specifically charged to secured creditors.

A form is also provided in which the debtor has to set out fully the whole of his property apart from book debts, for which a special sheet is provided. A separate form is also supplied for any bills of exchange which he has on hand available as assets. When these forms have been completed they are summarised on a sheet in the following form, this sheet being known as the *Front Sheet*:

that some creditors, being given by law a special priority or preference, are entitled to payment in full before the ordinary creditors receive anything. The amount of their claim is, therefore, deducted from the total of the assets and the balance is the amount available for the ordinary creditors.

From the nature of the necessity of the preparation of the statement of affairs it is unlikely that the assets will exceed the liabilities, and there is, therefore, generally a deficiency of assets to meet the claims of the creditors. Even when a surplus is shown on a statement it is nearly always illusory and arrived at by the extravagant valuation of assets.

Deficiency Account. When a deficiency is shown it has to be explained in a further sheet, known as the *Deficiency Account*. It is required that this shall cover at least a year before the receiving order and begin, where possible, at a time when the debtor has a surplus of assets over liabilities. The object

STATEMENT OF AFFAIRS OF G. BLACK ON 30TH JUNE, 1906

Gross Liabilities	Liabilities (as stated and estimated by the debtor).		Expected to Rank.	Assets (as stated and estimated by the debtor).	Estimated to Produce.
865	Unsecured creditors as per List A ..	..	865	Property as per List H, viz.:	
250	Creditors fully secured as per List B ..	250		Cash at bankers	8
	Estimated value of security	300		Do. in hand	15
				Stock-in-trade (cost £500) ..	250
	Surplus carried to contra	£50		Furniture	50
187	Creditor partly secured as per List C	187		Life Policies	—
	Estimated value of security	150	37	Other Property, viz.:	
				Shares in copper mine ..	10
56	Liability on bill discounted other than			Book Debts (List I);	
	debtor's own acceptances (List D)	56		Good	75
	Not expected to rank against assets			Doubtful 123	
				Bad 200 ..	
200	Contingent or other liabilities (List E)	200		—323	
				Estimated to produce ..	50
	Of which it is expected will rank			Bills of Exchange on hand	
	against the estate for dividend ..	..	100	(List J)	25
25	Creditor for rent recoverable by distress (List F)	25		Surplus from securities as per contra	50
	Creditors for rates, taxes, and wages (List G) payable in full	33			533
	Deducted contra	58		Deduct Creditors for rent, rates, etc.	58
					475
				Deficiency explained in Statement K	527
1,583			£1,002		£1,002

Front Sheet. It will be observed that this statement resembles in some degree an ordinary balance-sheet, in that it is intended to show the assets and liabilities of the debtor. A balance-sheet of a going concern is, however, prepared upon the assumption that there is no immediate necessity for the realisation of the property; which can therefore be stated at its value to the proprietor from the view of utility. The property of the debtor, on the other hand, is valued upon the basis of early realisation; it may be as a going concern, but is probably at break-up prices. It will further be noticed

of the deficiency account is to show how that surplus has disappeared, and how the deficiency shown on the front sheet has arisen. The account, therefore, is largely in the nature of a profit and loss account and is made up in the form as shown on next page.

The complete statement of affairs has to be verified on oath by the debtor and lodged with the Official Receiver, who calls a meeting of the creditors to decide the course to be taken in dealing with the estate. They may decide to wind it up in bankruptcy, and apply to the Court to adjudge the debtor a bankrupt. If they take this course a trustee may be

appointed at the meeting who will, after certain formalities, take over the assets from the Official Receiver and proceed to realise them for the benefit of the creditors. When they are fully realised, he distributes the proceeds amongst the creditors pro rata, after first paying his own remuneration and the costs and expenses of the bankruptcy proceedings. The distribution of a bankrupt's assets amongst his creditors is called a dividend.

Public Examination and Discharge. After the meeting of creditors, the debtor has to attend for his public examination, which consists of an appearance in open court, when he is questioned by the Official Receiver, the trustee, and any creditors who may so desire as to his past dealings with his property. After the public examination has been concluded the debtor may apply for his discharge from his bankruptcy. This application is heard in open court, and notice of the hearing is sent to all the creditors. At the hearing the Official Receiver reports the result of his investigations into the debtor's conduct and affairs, and the trustee and creditors may then be heard against the application. If the Official Receiver reports that the debtor has been guilty of certain offences the Court will either refuse the discharge or suspend it for not less than two years. The principal offences which will entail this consequence are inability to pay 10s. in the £, trading with knowledge of insolvency, speculation, failure to keep proper business books, fraud, and previous bankruptcy. If the discharge is granted the debtor is relieved from all liability for debts incurred prior to the receiving order but for one or two unimportant exceptions. A bankrupt who has not obtained his discharge is not allowed to contract a debt of £20 without disclosing the fact that he is an undischarged bankrupt. If he should do so he renders himself liable to imprisonment.

Compositions. To go back a short distance, it should be mentioned that the debtor sometimes brings forward at the meeting of creditors a scheme of arrangement or a proposition to pay a composition of not less than 7s. 6d. in the £ in consideration of being discharged from his liabilities. If the proposal is approved by a majority in number representing three-fourths in value of the creditors who have proved their debts, it is brought before the Court by the Official Receiver after the debtor's public examination has been concluded. The Official Receiver reports upon the scheme or proposal, and if the Court is satisfied it is for the benefit of the creditors, the arrangement is sanctioned, and the debtor thereby relieved from the various disabilities of bankruptcy.

Reference has been made to creditors who have proved their debts. This relates to the manner in which creditors are required to lodge their claims in bankruptcy proceedings. When the Official Receiver issues notices for the meeting of creditors he sends out also what is known as a form of *proof of debt*. This is a skeleton form of affidavit which has to be completed and sworn by the creditor. It states that the debtor was, at the date of the receiving order, and then is, indebted to the person on whose behalf the proof is lodged in the sum named therein, and for the consideration stated. Any security held by the creditor has to be fully stated in the proof and valued. In order that the valuation made by the creditor shall be a fair one, the Official Receiver or trustee has the right in certain circumstances to call upon the creditor to deliver the security to him upon being paid the amount of the valuation. When no trustee is appointed at the meeting, the Official Receiver acts in that capacity.

DEFICIENCY ACCOUNT.

Excess of Assets over Liabilities on 1st July, 1905	1,000	Net loss on trading from 1st July, 1905, as per books of business ..	221
Deficiency as per Statement of affairs	527	Bad debts as per schedule	273
		Expenses incurred since 1st July, 1905, other than trade expenses, viz., household expenses of self and wife	360
		Other Losses and Expenses :	
		Copper mine shares	40
		Loss on bills discounted	100
		Losses by Stock Exchange speculations	533
	£1,527		£1,527

Trustee's Accounts and Release. Accounts have to be kept by the trustee, showing the realisation of the estate, and the manner in which the proceeds are dealt with. The accounts are audited twice a year by the Board of Trade. When the trustee has realised all the assets and distributed the sum available, he applies to the Board of Trade for his release as trustee. He must give notice to the creditors of his intention to do so, and send to each of them a summary of his receipts and payments, showing, on the one hand, the amount the assets have realised as compared with the estimate placed upon them in the statement of affairs, and, on the other, the manner in which the amount received has been expended in payment of court and other fees, law costs, remuneration, and dividends to creditors. The Board of Trade audit the accounts to the close of the trusteeship, hear any objections by creditors to the granting of the release, and either grant it or refuse it until the trustee has complied with their requirements.

Continued

CYCLOPÆDIA OF SHOPKEEPING

IRONMONGERS. Capital and Stock. Up-to-date Precautions in Buying. Stockkeeping. Profits. Working Departments

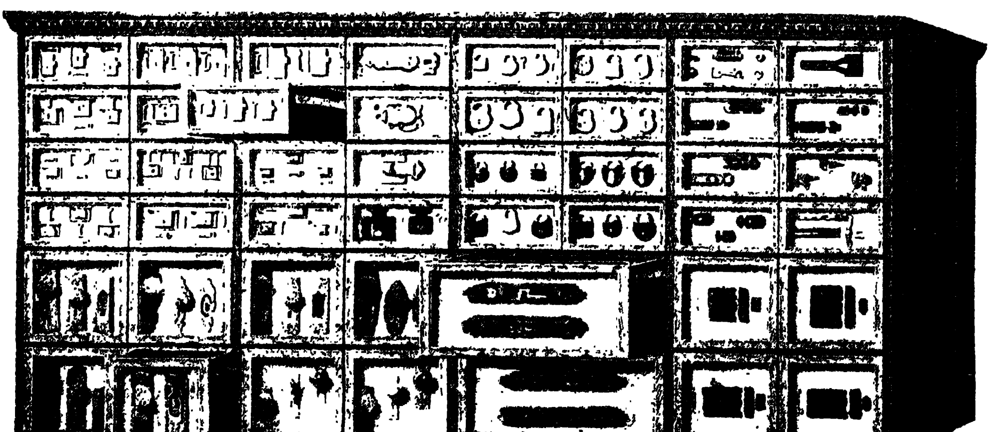
NO trade is more complex than that of an ironmonger. It embraces a dozen trades in itself, and no man has ever attained to a thorough knowledge of every branch of it. Many of the departments, which are sometimes separate trades, are considered independently in separate articles in this course. Our concern is with the young man who wishes to open shop as a general ironmonger. If he has had a practical training with an ironmonger, the branches which he will cultivate will vary from those he will exploit if he has capital, but little practical experience. Undoubtedly the easiest department to enter and understand is that of household ironmongery. Builders' and black ironmongery consist of merchandise which becomes familiar only after long acquaintance. Hence the competition of the draper and the stores is in household ironmongery. Neither class of opposition has entered seriously into the black and heavy departments.

Capital. The annual turnover of the ironmonger is seldom more than double the amount of capital sunk in stock. In a small concern, where hand-to-mouth buying is practised, the year's turnover may rise to three times the stock value, but such a case is exceptional. Hence, for a turnover of £1,000 per annum, the capital available should be not less than £500 if anything is to be allowed for shop fittings and a few pounds for cash in hand. The apportioning of capital upon stock must be decided by local conditions and the class of trade the ironmonger wishes to develop. The five-shilling handbook, "The Modern Ironmonger," published at 42, Cannon Street, London, E.C., suggests division as follows, and the allotments are as reasonable as any general advice can be:

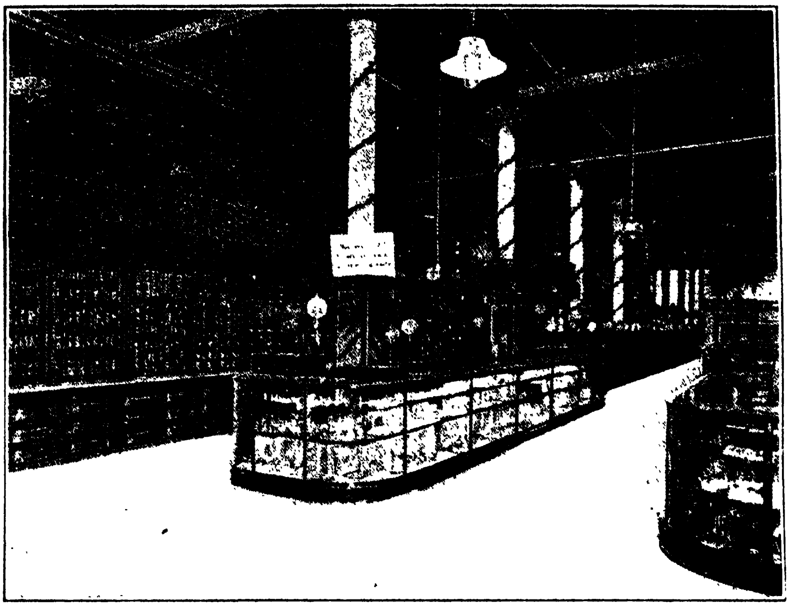
	£
Fixtures, counters, etc.	60
Stock, general and furnishing, including hollow ware and enamel ware	250
Tools and cutlery	50
Brassfoundery	25
Black and builders' hardware	40
Sundries	40
	£465

The book mentioned is a valuable practical guide to anyone contemplating establishment as an ironmonger.

Stockkeeping. The interior of the old-time ironmonger's shop is conspicuously void of attractiveness. The science of stockkeeping does not find in the ironmongery trade the following which it does in other departments of retailing. To draw lessons from up-to-date stockkeeping for ironmongers we have to cross the Atlantic. Many of the "hardware stores" in the United States and Canada lead instead of lagging behind in efficiency and attractiveness of shopkeeping methods. So thoroughly is the need for proper system recognised that there are a few business houses there who devote themselves exclusively to the making and purveying of hardware shop fittings, and they seem to thrive. We select from American practice some up-to-date shopfittings, and it will be admitted that by system carefully calculated to suit the different departments of a hardware stock, an ironmonger's shop may be made to



1. UP-TO-DATE SYSTEM OF STOCKING SHELF HARDWARE



2. THE INTERIOR OF A MODEL IRONMONGER'S SHOP

look as attractive as that of any other tradesman. Fig. 2 is an illustration of a modern American hardware store where properly designed fittings have enabled the paper parcels to be discarded, and nothing meets the eye but drawers, lockers and glass cases. Figs. 1 and 3 show in greater detail the system of fixtures adopted. The latter arranged for tools, is self-explanatory; the former, shows the drawer system of keeping builders' hardware and brass foundery, each drawer having in front a glazed compartment in which is placed a sample of the contents of the drawer. The value of such an arrangement for indicating the nature of the stock without deterioration is obvious.

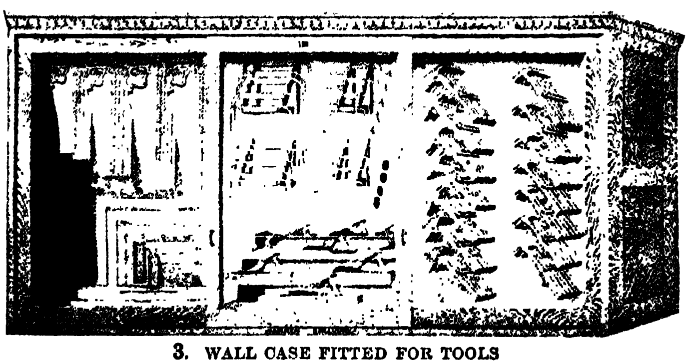
The next illustration [4] is of an American nail counter, each nail bin being mounted upon an axle which permits it to fulfil its function much better than the ordinary fixed bin. The show stand for scythes [5] is convenient in that it displays the articles well, and offers no risk of injury by exposed cutting edges. The shot case [6] is devised so that each turn of any handle below a glass disc admits into the drawer beneath exactly one pound of the shot, so that to extract 7 lb. of any desired size of shot it is necessary only to turn the proper handle seven times, after which the scooped-shaped drawer, the handle of which is visible, contains what is wanted.

Home-made Fittings. But apart from special fittings such as we have described, the ironmonger may improve his shelves by acting as carpenter. Hardware shelf boxes may be purchased, but they may easily be made by taking two stout pieces of wood of equal size to serve for back and front, and by fitting to these a piece of sheet iron bent to form sides and bottom. Fig. 7 shows a fitting for keeping orderly stock of ropes in coils. The coils are beneath the floor, and a spring clip is fixed beneath each hole to prevent the rope running back. Fig. 8 represents a shelf fitted by an ironmonger's assistant with horizontal dividing shelves of wood and small vertical partitions of sheet iron cut to size. It would be difficult to improve upon such an arrangement for edge tools, such as bits, chisels, plane irons, etc.

The list of shop fittings given is intended to be suggestive, not exhaustive. Almost every class of ironmongery may be better stocked by special cases or fittings purchased or home made, and the result of their use is better kept stock and prompter service.

Shop Assistance. The ironmonger who begins business on the minimum capital possible will not need much shop assistance. The help of an apprentice, message-boy, or porter will suffice. But it is to be hoped that trade will develop quickly, and bring the need for other help. It is a common saying in the trade that one assistant or apprentice is required for every £1,000 of turnover. This will be found to be approximately accurate.

Ironmongers' assistants are badly paid, although probably not worse than the average

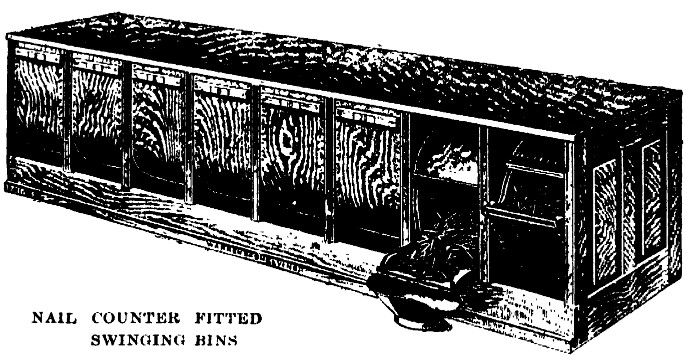


3. WALL CASE FITTED FOR TOOLS

shopkeeper's assistant. A few years ago the writer investigated this subject to some depth, and found that the average salary asked by over 100 assistants applying for a situation as chief assistant was about 30s. per week. In London, a good young assistant can be engaged for this sum, and in the provinces 25s. or even less will secure the services of a youth who has passed through a good apprenticeship training.

Quality of Assistants. There have been many complaints regarding the poor quality of the present-day ironmonger's assistant. There is reason in the complaint. Good men have ambitions, and in view of the fact that the capital necessary to open shop is large in comparison with other trades, ambitious men without capital are prone to enter other spheres, leaving the mediocre and poorer members to pass their days behind the ironmongery counter.

The Ironmongers' Federated Association has recently embarked upon a scheme of practical examinations for assistant ironmongers in the hope of raising the quality. The scheme has up to now achieved only moderate success. It has not been shown that the certificate of the Association carries with it an extra 5s. a week in remuneration, and assistants grudge the time and effort to qualify for the diploma. But, apart from direct and immediate pecuniary gain, the examination is an excellent thing, and a certificate stamps the man who has won it as having aspirations towards a knowledge of his trade far above the average.



NAIL COUNTER FITTED SWINGING BINS

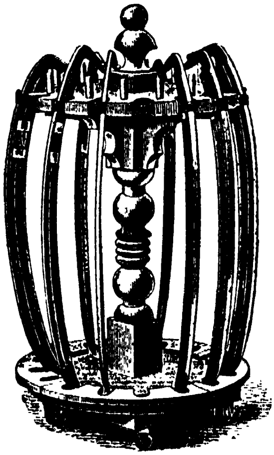
Buying. The success of a retail ironmonger is primarily a question of successful buying. It is a good rule to strive to build up a stock the individual articles in which are different as far as possible, from those stocked by competitors. For staple articles—nails, netting, hinges, and other things—this is impossible, but by seeking different patterns in household ironmongery, brassfoundery, and other classes where variation is possible, better prices are usually obtainable. It is usually difficult for the man who has been wont to buy in fair quantities for an employer in a large way of business to reduce the orders to the requirements and capital of his own modest start, and shipwreck has often been made from this circumstance. When accounts fall due for payment, a sovereign in hand is worth two locked up in shelf stock. Therefore the necessity to preserve a cash balance in hand, even if the stock suffer thereby, is imperative. Money is to be saved by taking advantage of cash discounts, and this cannot be done without the cash available as cash.

Factors versus Manufacturers. The factor—that is, the City wholesaler or commission merchant, who was always formerly the medium through whom hardware merchandise reached the retailer—is becoming a less important quantity in trade relation. The tendency is all towards the manufacturer getting into direct touch with the retailer. Indeed, the tendency is, in some directions, much further. It is sometimes that the maker gets into direct touch with the consumer. The policy of the retail ironmonger is, of course, all against direct trading between the maker and the consumer, and he will encourage firms who refrain from this undesirable but not infrequent practice. But he will, on the other hand, strive to purchase as much of his stock as possible from the makers and not from factors.

At first, especially if he begin business on small capital, this will be difficult, but as he feels strong enough to order individual "lines" in larger quantities he will pass the factor for the manufacturer. It will not be possible to dispense with the factor entirely. For imported goods, for instance, German, French, and American, the factor must be patronised. He may often be patronised unwittingly. A professing manufacturer may factor half the goods which he catalogues, as, indeed, nearly every Birmingham brass-founder does, although few retailers know it, but as a general policy the retailers will try to cultivate relations with the manufacturer in preference to the factor.

Catalogues. In a retail trade so diverse in its character as that of the general ironmonger it is impossible to hold in stock everything that may be asked for, and in no branch of shopkeeping is there greater need for a good system of keeping ready for reference a good range of illustrated catalogues. It is not enough that such catalogues should be in the office; they must be arranged and classified in such a manner that they may be placed before the customer at any required moment. Then there must be no need to spend time hunting for "that last quotation" to know what discount the catalogue prices bear. When a uniform discount prevails upon all the goods shown in a given book, it is an easy matter to have that discount indicated in cipher on the front of the catalogue or other readily accessible place. Where different discounts apply throughout a book, it means a little more work to record the details, but it is none the less essential.

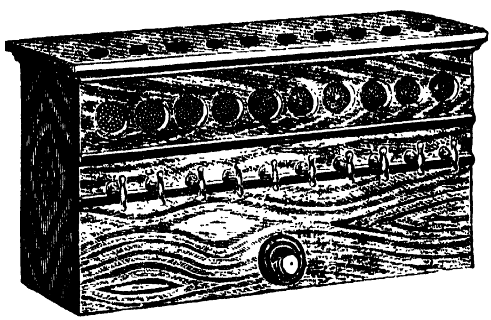
Special Orders. Naturally, only price lists and catalogues which carry discounts sufficiently large to constitute a reasonable profit are shown to customers. In these days there are few maker's catalogues which do not fulfil this requirement. It is always well to exhibit to the purchaser catalogues carrying good long discounts. Assume that a special size of fishkettle has to be brought from Birmingham, the profit may vanish under the carriage charge if the trade discount be only 33⅓ per cent., but if a 50 per cent. catalogue be shown and list price be secured there is a good profit left after paying carriage. The customer is seldom willing to pay any special charge caused by filling an urgent requirement. He usually considers that this charge should come from the retailer's profit. Another reason for preferring the long discount catalogue when taking a catalogue order is that it gives the opportunity to allow something off. The purchaser thinks he has a far better bargain at 15 per cent. from a 50 per cent. list than when he pays list price from a 33⅓ per cent. catalogue, although the former transaction yields the ironmonger a larger commission.



5. DISPLAY STAND FOR SCYTHES

Trade Discounts. In no trade is the system of trade discounts so complex. The ironmonger who understands all about trade discounts has a clear head. There are some articles which are subject to say, 80 per cent. discount, not many, perhaps, but enough to enable this to be taken as an example.

To the man with a non-mathematical head and no trade experience it would seem that to sell such goods at 75 per cent. from list would be ruinous, whereas, in fact, the practice shows a 25 per cent. profit on cost. The instance may be given in illustration of the need for careful figuring in calculating prices by discount, especially if the discount be a long one.



6. A CONVENIENT SHOT CASE AND MEASURER

Goods should be priced on a discount basis. This is the only way to preserve uniformity in selling prices, which is desirable. The customers should not, of course, be initiated into the mysteries of the discount system, as the knowledge furnishes them with a lever of comparison which may prove exceedingly inconvenient for the retailer.

Price Maintenance. There has been much talk of price maintenance in ironmongery during the last few years. Although the attention which the subject has received at meetings of ironmongers' associations and in the trade may convey the impression that the movement towards the maintenance of minimum retail prices has acquired a strength and achieved a success greater than actual facts warrant, yet the practice is becoming fixed and is taking deeper root, thanks to the combination of ironmongers in trade associations. Fixed retail prices can be maintained by two methods, by the manufacturers insisting that purchasers of their goods must send the article purchased only upon certain conditions, and by a combination of all the retailers in a specific area under mutual agreement to maintain certain prices upon certain articles. The former method, that where the law is enforced by the manufacturer, is applicable only to proprietary articles—a specific carpet sweeper, a certain cartridge, a peculiar make of lawn mower, for instance—but is unsuitable for general classes of hardware made by many competing manufacturers. On the chief articles of sale, which have little or no distinction in pattern, although made by many makers, price maintenance is only feasible by harmony between the retailers in the district constituting the field of trading. It is often difficult to secure this harmony. One recalcitrant member of the trade may prevent other 49 members desirous of uniformity in selling policy from practising that uniformity.

Manufacturers who adopt the price-maintenance scheme seldom insist upon the maintenance of full list prices; they usually stipulate only that there must be no cutting lower than a certain figure. Thus, most manufacturers of lawn mowers, who allow 30 or 33⅓ per cent. trade discount from list prices, permit purchasers to sell at 15 per cent. from list. Carpet-sweeper makers and a few other makers of proprietary articles of hardware follow similar systems.

Profits. The articles upon which retailers have arranged to maintain minimum prices are comparatively few, and the practice has a hold only upon isolated districts. Wire netting is the article which has received the greatest attention, and in some districts agreement has stopped the senseless habit of giving what is practically change for a sixpence and calling it carrying on the business of an ironmonger. A leading ironmonger recently proposed in the columns of "The Ironmonger" certain rates of profit which certain representative classes of hardware

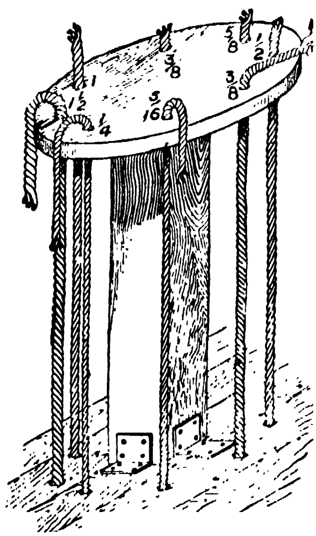
should carry. The rates are reasonable, and worthy of being put on record here:

	per cent.		per cent.
Axles and springs ..	20	Hollow-ware	35
Agricultural implements	20	Hurdles	15
Bar iron, sheet iron, girders, steel	15	Lawn-mowers ..	17
Baths (cast) ..	20	Lead and glass ..	15
Bicycles	25	Mangling and wringing machines ..	
Belting	25	Nails	
Corrugated sheets ..	15	Oil-engines	
Coffin-furniture ..	25	Oils (linseed, turpentine, machine oils, etc.)	
Cement	20	Perambulators ..	
Dairy-machines (separators, churns, butter-workers) ..	20	Paints and varnishes	
Enamelled slate and wood mantelpieces	20	Rainwater goods ..	
Fencing-wire	20	Ropes	
Files	25	Spades, forks, shovels, scythes ..	
Felt	25	Sash-weights	
Grates and ranges, registers, stoves, mantel-registers	20	Weighing-machines, platform - machines, coal-machines, etc. ..	
Gas-stoves	20	Wire netting	
Garden-seats and garden furniture generally	25	Wrought-iron tubes	
Garden-hose ..	25	Brassfoundery, locks, hinges, screws, etc. (for builders) ..	20

These percentages are intended to be calculated upon selling prices, not upon cost prices, a point of some importance, as there is a material difference between the two. They must necessarily be considered as elastic in their application to different districts. Even given agreement between the hardware retailers in a certain area, any scheme of selling prices would have to consider the amount, strength and policy of competition from neighbouring commercial centres operating in the district. Much of the ironmonger's trade is of a semi-wholesale character—selling to builders, carpenters, and others, who expect to purchase under the usual retail prices, and the competition for whose custom is keen. It were useless for the local ironmongers to demand a 20 per cent. profit on nails if the travellers from an ironmonger in a town twenty miles off work their customers offering these goods upon a profit of 1½d. or 3d. a bag—pursuing the policy of setting a sprat to catch a whale.

Tendering. Much of the business of many ironmongers comes in the form of orders secured only by competitive tender, and all who know anything of this class of trade know with what complaint it is carried on. Competition, which is the life of trade, is the slayer of profits, and competitive orders such as come in the way of the ironmonger are usually secured only by cutting down profits to the point of invisibility or beyond. Where association among all those tendering can be secured, agreement is possible, and reasonable profits attainable, but association to this end can seldom be attained. Under ordinary conditions, the ironmonger must recognise that he cannot secure an order in competition and a direct profit at the same time. Therefore, he must work for an indirect profit. Where the man, firm, company, or corporation placing orders by tender never give the opportunity of indirect profit, the better policy is to refuse to waste time in drawing up an estimate, leaving the business to those foolish enough to wish for it on its merits or demerits. There are always such competitors, and they may be left to stew in their own juice. But where a profit may honourably be worked in edgeways the trade may be worth having.

A Sprat to Catch a Whale. Let us take, for example, a workhouse, hospital, or municipal department, the year's contract for ironmongery in which is to be placed by competitive tender. It may be necessary to quote upon a profit basis of 10, 5, 2½ or even 0 per cent. to secure the order. If the extras which may be expected to accrue, and which are not covered by the schedule prices, promise to yield a reasonable, even if low, profit out of the whole contract, it is worth securing. There is always a little prestige attaching to a successful contractor under competition, and this is not quite a negligible quantity. Should the tradesman under such conditions charge fairly high prices for the extras, thereby getting "a little of his own back," he can scarcely be charged with either moral or commercial transgression.

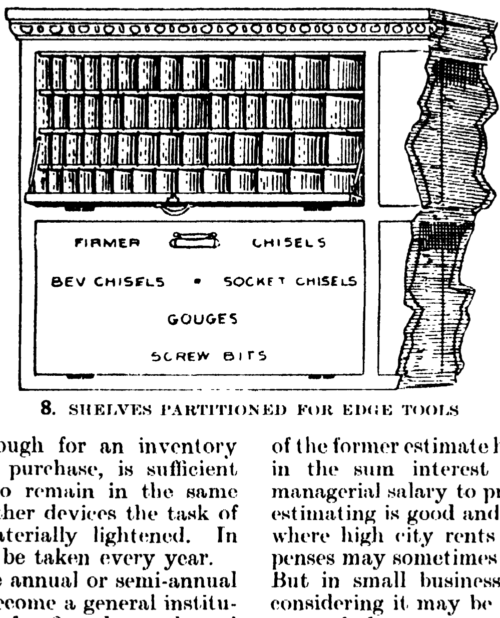


7. ARRANGEMENT FOR STOCKING ROPES

A Case in Point. There are many cases where an apparent no-profit transaction is more directly remunerative. Let us suppose that a private individual is erecting a villa—an event which does not happen often in his lifetime. He is fastidious in his choice of grates, stoves, bell-fittings, chimneypieces and tile hearths. He probably goes the rounds of the local ironmongers inspecting stock and getting quotations. There is probably a certain make of kitchen range popular in the district, and one is certain to be included in the order. The ironmongers quote a low price for this stove, cutting the profit down to nearly nothing. The tradesman who makes a daring cut to a half-sovereign under cost price will secure the order. His fellows will wonder if he has developed into a philanthropic institution, and will predict his speedy appearance in Carey Street. But he may be the wisest man in the crowd. The purchaser is probably ignorant of the respective values of the other items in the bill he is mounting up.

Hearth tiles, which cost 7s. 6d. a yard, may be sold him for 20s. or 25s. a yard, if they please his fancy. A few chimney-pieces may be selected carrying something approaching 100 per cent. profit on cost, and the half-sovereign thrown away may return fifty times its value in net profit. The ability to profit by occasion such as this, to estimate its value, and to act accordingly, goes a long way to make the success of a modern retail ironmonger.

Stocktaking. Every business man should make a periodical inventory of his stock. Ironmongers are given to obey this rule less than other shopkeepers. There is some reason for their reluctance to take stock. It is no light undertaking. It is at the least a two or three weeks' job, and if things seem to be going well there is a great temptation to drive the old ship along without casting the log. But there is a double reason for taking stock. Not only does it indicate the value on the shelves, but it also gives a periodical opportunity to clear out old stock and sell it before its value has deteriorated further. The task of stocktaking may be simplified somewhat by following certain methods. For instance, wire netting may be weighed instead of being measured, and the measurement may be calculated from tables showing the relation of weight to length in the various widths, meshes and gauges. Oils may be treated in the same way. A system of stocktaking of household and cabinet brassfoundery by weighing it is given in the "Ironmonger Diary" for 1903. It is approximately accurate, and while not good enough for an inventory for purposes of sale or purchase, is sufficient where the business is to remain in the same hands. By these and other devices the task of stocktaking may be materially lightened. In any event, stock should be taken every year.



8. SHELVES PARTITIONED FOR EDGE TOOLS

Cheap Sales. The annual or semi-annual cheap sale has not yet become a general institution with ironmongers. A few firms have adopted this method of clearing off soiled or doubtful stock, and the fact that firms who have once gone in for this usually maintain it as a periodical event is the best recommendation for its value. One has only to attend an auction at which the stock of a very old-established ironmonger's is being realised, to be impressed with the mass of absolutely unsaleable stock which has accumulated. Much of it fetches the price of old metal, or a little more. The process of deterioration has been gradual. Had the goods been sold at cost price just when they began to go off, or at a little less a little later, their holders would have suffered far less loss. Not only would more hard cash have been got than was ultimately realised, but the room which things took up could have been devoted to more saleable goods. The ironmonger is, as a rule, far too loth to "cut his losses." Where a remnant might have been saved, he hangs on to the lot till all is gone. It is to be remembered in business that stock once deteriorated will never regain its original value, and no tradesman is more oblivious to this fact than the ironmonger.

Departments and Side-lines. There are many departments and side-lines to the ironmongery trade which are the subjects of special articles in this course, and which may therefore be passed with bare mention. They include agricultural implements, domestic engineering, bags and trunks, china and glass, cutlery and tools, cycles, guns and ammunition, fishing tackle, plumbing, baby-carriages, house furnishings, motor-cars, toys and games, and sewing machines. The suitability of a department or side-line depends upon premises, locality, competition, fashion, capital and taste, and upon these points every man must decide for himself.

Working Expenses. The working expenses of an ironmonger's business are a very variable quantity. We noticed in the leading trade paper a few weeks ago that a prominent Liverpool ironmonger stated that it costs on an average $22\frac{1}{2}$ per cent. to run an ironmonger's business, while a few weeks before another retailer not many miles away put the percentage as 10 per cent. The one was too low, and the other too high. It is evident that the framer of the former estimate had reached it by including in the sum interest on capital, or, at least, managerial salary to principals. This method of estimating is good and safe, and we believe that where high city rents have to be paid the expenses may sometimes be as high as $22\frac{1}{2}$ per cent. But in small businesses such as those we are considering it may be taken that 15 to $17\frac{1}{2}$ per cent. of the turnover is swallowed in working expenses. Were the beginner to frame his prices upon the groundwork that expenses were $22\frac{1}{2}$ per cent., he would probably starve for lack of trade. An old-established and a high-class business may flourish under a reputation for high prices if excellence and variety of stock be an accompanying feature, but the small beginner, whose stock, though good, cannot claim wide variety, would commit commercial suicide by attempting to build up a trade on high prices.

The Ironmonger's Workshop. Whatever may be said about the selling of ironmongery goods, it must be allowed that the trade is not prosecuted to its widest scope if

the business does not include a working department.

Capital invested by an ironmonger in workshop equipment and material ought to yield much more profit than a similar sum spent upon stock. So much of the workshop turnover is labour, which involved practically no capital charge, being merely drawn upon as required, that it is much more remunerative than a ordinary merchant business. The materials also upon which workshop labour is expended—bar and sheet iron, tin plates, copper and brass, zinc and lead—are semi-raw materials, which cost much less in proportion to bulk than ordinary shelf hardware. Should there be two ironmongers near each other, one of whom has workshop facilities and the other has not, much merchant trade is caught in the net of the former on account of his ability to instal the ranges, heating and lighting apparatus, electric bells, pumps, and sanitary fittings which he sells, and from his ability to repair anything from a tin tea-bottle to a motor-car.

An Ideal Partnership. The ideal partnership for two young men beginning business together as ironmongers is found when one is skilled in buying and selling stock, and in window-keeping and office work, while the other is a practical man competent in one or more working compartments, and able, if he cannot himself do all classes of bench and fitting work, at least to supervise practically men who can, and to prevent the issue of badly-executed work and the waste which robs many an ironmonger of the profits which should accrue to him from his workshop department.

Should two young men such as we have indicated decide to run a double business of this nature, the most promising location for them is near a large and flourishing ironmongery concern without workshop facilities. Then, by pushing the working department for all it is worth, they may without difficulty alienate a good deal of the custom of the older establishment, as they have a powerful weapon of competition which the other has not at command.

Working Departments. Many considerations influence the nature of the work to be undertaken by the ironmonger. At the initiation of the enterprise the scope cannot usually be very wide. It is always well to have a main working department upon which others may grow with expanding trade as the need arises. Tinsmithing is a very frequent mainstay of an ironmonger's workshop. It has this merit—that slack times can always be employed in making for stock, and whatever may be the principal workshop output, it is always well to select something which can be made for stock. Such a practice has in it the germs of development into an important manufactory. Many large manufacturing concerns throughout the country have grown from small beginnings in an ironmonger's workshop.

Other possible workshop departments include domestic engineering, the repair of agricultural implements, agricultural engineering, smith work of various classes, sheet-metal work, electrical engineering, plumbing, foundry work, cycle and motor repairing. Many of these departments are considered in separate articles of this course, and it were idle repetition to enter into details of all of them here.

Text-book Aids. There are some text-books which the ironmonger will find useful guides in his workshop practice. The best practical handbook covering general work is "The Ironmonger's Workshop," the 5s. volume recently published by "The Ironmonger," of 42, Cannon Street, London, E.C.; and for the list of separate text-books devoted to specific branches the following may be recommended:

"Metal Plate Work," by C. T. Millis, M.I.M.E. (E. & F. N. Spon, Ltd.), 9s.; "The Sheet Metal Worker's Instructor," by Warn & Horner (Crosby Lockwood & Son, 7, Stationers' Hall Court, E.C.), 8s.; "Warming Buildings by Hot Water," by Frederick Dye (E. & F. N. Spon, Ltd.), 8s. 6d.; "Practical Electric Bell Fitting," by F. C. Allsop (E. & F. N. Spon, Ltd.), 3s. 6d.; "Telephones: their Construction and Fitting," by the same Author (E. & F. N. Spon, Ltd.), 3s. 6d.; "Wiring for Electric Light," by C. Metcalfe (Harper & Bros.), 5s. 6d.; "Lighting by Acetylene," by Frederick Dye (E. & F. N. Spon. Ltd.), 6s.; "External Plumber Work," by John W. Hart (Scott, Greenwood & Co.), 7s. 6d.; "Practical Sanitary Engineering," by Francis Wood (C. Griffin & Co., Ltd.), 8s. 6d.; "Construction and Working of Pumps," by G. C. R. Marks (J. Heywood), 3s. 6d.; "Hydraulic Rams," by J. W. Clarke (B. T. Batsford), 2s. 6d.; and "Modern Foundry Practice," by John Sharp (E. & F. N. Spon, Ltd.), 21s.

Workshop Economy. It is the intention, of course, that the workshop should be carried on at a profit. Though it may be made the most remunerative department in the whole business, it is the department in which money may most easily be lost. The lack of a good system of checking and pricing all work, and of seeing that every half-hour spent upon a job and every item of material are charged for in the final bill, often diminish the workshop profit considerably, sometimes even wiping it out altogether. Workmen need watching. So many bad and indifferent workmen are available that good workmen once engaged should be retained even at some inconvenience when business scarcely warrants retaining them. It is then that the value of making goods for stock comes to be appreciated.

Workshop accounts demand care. The filling in of the details of material on a job should be carefully verified, and only someone absolutely trustworthy and accurate should be trusted with this work. The omission to charge a half pound of solder on a job may seem a small matter, but if repeated half-a-dozen times a day for 300 days in the year means a loss of £40 a year. Careful checking by a system, even if it cost the wages of a man somewhat more expensive than an ordinary workman, is always a wise economy.

Continued

ELECTRICITY AT REST

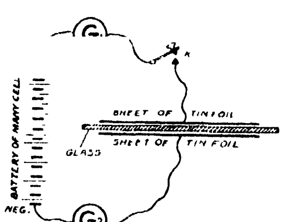
Charges and Discharges. Condensers. Capacity of Different Materials for Condensers. Leyden Jars. Energy of a Charge

Continued from page 3422

By Professor SILVANUS P. THOMPSON

THROUGHOUT almost the whole of the preceding articles we have been dealing with electricity in movement, flowing as a current, since almost all of the useful effects due to electricity occur in consequence of its being in motion. We have now to consider certain particular effects or properties which belong to electricity *in the state of rest.*

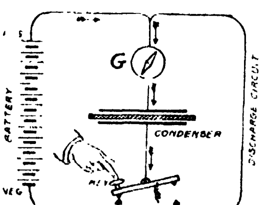
An Experiment. We shall first describe an experiment that is of some significance. Let us arrange a circuit as if we were trying to send a current through a sheet of glass, or of some other non-conducting substance. As the sheet does not conduct, no current will go through it—at least unless we employ so enormous an electromotive force (such as 100,000 volts or more) as to pierce a hole in the glass. It may seem absurd to try to send a current through a non-conductor; but the experiment is instructive. Procure a battery of a considerable number of small cells—50 Leclanché cells in series, or better still, 100. Have also a sensitive and quick-acting galvanometer, such as a Thomson mirror galvanometer, and a simple key, and let some sheets of tin-foil be also provided, and a large thin sheet of glass. This apparatus is then to be set up in the manner depicted diagrammatically in **217**. Cut two sheets of tin-foil so that each is a little smaller than the sheet of glass, so that if laid down on the glass it would leave about ½ in. of margin all round. Lay one sheet of tin-foil down on flat wooden table, place the sheet of glass over it, and the other sheet of tin-foil on the glass. Then join the battery to the two pieces of tin-foil with thin wires, connecting into the circuit the galvanometer G [**217**] and the key as shown in the diagram. The galvanometer may be placed at either of the positions shown. In fact, its particular position in the circuit is immaterial. All being ready, let contact be made by pressing down the key. It will be quite impossible to find any trace of current of a steady kind, for as a matter of fact, the glass sheet lies across the path and completely cuts off all current from flowing. And yet, if the experiment be very carefully made, and the galvanometer be sensitive enough, it will be found that when the key is first depressed there is a momentary disturbance of the galvanometer needle, indicating that on closing the circuit there is a transient rush of current; but it stops at once, leaving no permanent deflexion. In fact, what happens is this. The battery possesses an electromotive force by virtue of which it is always tending to drive a current through itself, though no current can flow until a circuit is provided. When the wires leading to the two sheets of tin-foil are made part of the (incomplete) circuit, on the pressing of the key there is a movement of electricity; for the battery is then able to move a small quantity of electricity along, drawing it out of one tin-foil (that connected to the negative pole) and driving it into the other tin-foil (that connected to the positive pole). It cannot produce a true circulation of current because the glass stops the way. In other words, the battery pushes a certain small quantity of electricity along the conducting path as far as it can go—that is, until it is stopped against the face of the glass plate, and at the same time it draws an equal quantity from the other side of the glass plate.



217

Charge and Discharge. The glass plate in the foregoing experiment is said to receive a *charge*. The word *charge* means a quantity of electricity at rest. The place where a charge is to be found is on the surface of a non-conductor. If electricity has been running *to* a surface of a non-conductor, and accumulates there, it is called a *positive charge*. If some electricity has been removed from a surface, so that there is a deficiency there, that surface is said to have acquired a *negative charge*. In the experiment above-described of charging a glass plate from a strong battery, the act of charging consists in producing a *positive* charge on one face and an equal *negative* charge on the other face.

A more convenient way to study the matter is to arrange the apparatus as snown in **218** and **219**, with a discharge circuit as well as a charge circuit, worked by a Morse key, the middle-point of which is connected to one of the tin-foils. The toe of the key, when pressed down by the spring below it, makes contact with the discharge



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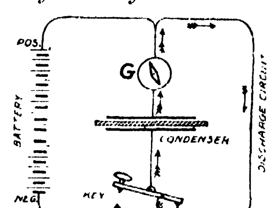


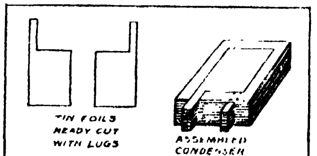
219

wire. When the handle of the key is depressed the discharge contact is broken, and instead the heel of the key makes a contact with the charging circuit, so that the battery can charge the sheet of glass. With this arrangement there will be observed in the galvanometer [G] a momentary movement of the needle, indicating a rush of current during *charge*, followed, when the key is released, by another movement of the needle in the opposite direction, indicating the rush of the current back, during discharge. It will be found that these two rushes of current are equal.

Condensers. Any such arrangement of a layer of non-conducting material such as glass between two conducting coatings of metal is called a *condenser*, because it is thus able to condense electric charges upon its surfaces. If, in the experiment described, a sheet of glass has been taken that is small, only small quantities of electric charges can be condensed upon it, and the effects it produces will be small. Unless a battery of 40 or 50 cells be available, the galvanometer will scarcely detect any effect unless the sheet of glass has an available surface of 500 sq. in. or so.

The term *capacity* is used to indicate the electrical magnitude of a condenser. It is found by experiment that the capacity of a condenser depends upon three things: (1) its surface, (2) its thinness, and (3) its material. The capacity of a condenser is directly proportional to its surface; other things being equal, a condenser that has an area of 1,000 sq. in. on each of its surfaces has twice the capacity of a condenser that has only 500. Also, a condenser made of a non-conducting sheet that is $\frac{1}{8}$ in. thick will have double the capacity of one of the same area and material that is $\frac{1}{4}$ in. thick; for the thinner the layer (so long as it is not so thin as to be pierced mechanically by a spark) the more powerfully does it permit the condensing action to go on. Lastly, the different kinds of non-conducting material have each their own specific quality; thus a mica plate has a greater capacity than a glass plate of equal size and thickness.

Large Capacity Condensers. In order to obtain condensers of large capacity it is necessary to use more than one sheet. For example, if we have 50 sheets of thin mica, each 6 in. long and 4 in. wide, we may arrange them to make one condenser having a large surface by piling them up on one another with tin-foil sheets between them in the following way. The tin-foil sheets are cut in the shape shown in **220**, each with a projecting lug, of such a size as to leave a margin all round except where the lug projects.



220

One of these is laid down on a table with its lug towards the right, and a sheet of mica placed over it. On the mica is laid a second sheet, with its lug projecting towards the left; then another piece of mica; then a third tin-foil with its lug to the right; then another piece of mica, followed by a fourth tin-foil with its lug to the left; and so on with the whole series, alternate lugs projecting to right and to left. When completed, the pile is clamped together securely, and all the lugs of odd number are joined together to make one terminal, while all those of even number are clamped together to make the other terminal of the condenser.

Dielectric Capacity of Materials. Faraday made a number of condensers of different materials, but all of the same size, to see whether they had equal capacities. One of these contained only air between the two metal surfaces, and as this was found to have a smaller capacity than the others air was taken as the unit for comparison of one dielectric with another. Faraday gave the name of *dielectric* to any material which will thus act as a condenser, meaning by the term that electricity can act inductively across the material, though no electricity passes through it. All dielectrics are non-conductors, but two different non-conductors that are equally effective as mere non-conductors may differ considerably in specific dielectric capacity. Air being then taken as the unit, the dielectric capacity of other materials run from wax, which is about 2, indiarubber and gutta-percha, which are about $2\frac{1}{2}$, and glass, which varies from $2\frac{1}{2}$ to $3\frac{1}{2}$, up to 5 or 6 for mica. Glass is too brittle for most purposes, and air will not do, because it is too easily pierced by a spark, besides affording no mechanical support to the metal conductors. Mica has two advantages, in that it can be split very thin and yet remain strong, and that its specific dielectric power is high. But large sheets of it are expensive. If strong tissue paper, resembling banknote paper, be thoroughly dried and impregnated with pure melted paraffin wax it forms sheets that are excellent for condensers, and to which the necessary tinfoil coatings adhere readily. The condensers used in submarine cable service are usually made of paraffined paper.

Charge in Relation to Capacity. A charge being a quantity of electricity, the amount of it can be expressed in *coulombs*. The amount of charge that can be condensed in a condenser depends on two things—(1) on the capacity of the condenser; and (2) on the voltage used to drive the electricity into the condenser. Suppose we had a condenser of such a size that on applying an electromotive force of 1 *volt*, the quantity of charge that ran into the condenser at one side (as an equal quantity ran out of the other side) was one *coulomb*, then we should describe that condenser as having a capacity of one *farad*. But such a condenser would be impossibly large and expensive, and the practical standard of capacity is a condenser of only one-millionth part of the capacity named, and such a standard is described as having 1 *microfarad* of capacity. The quantity of electricity that runs in or out of a condenser can then be calculated by multiplying together the number that represents the capacity in *microfarads* and the number that represents the volt-

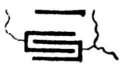
age of the battery, and then dividing the product by 1,000,000. Thus, if a battery of 120 *volts* be applied to a condenser having a capacity of 1·5 *microfarads*, the charge will be $120 \times 1·5 \div 1{,}000{,}000 = 0·000180$ coulombs.

Grouping of Condensers. Just as it is convenient in diagrams to use symbols for batteries and for galvanometers, so it is also useful to use a symbol for a condenser. This symbol [221] consists of lines drawn in such a way as to suggest the sheets of metal foil separated by a non-conducting space or layer.

SYMBOL OF CONDENSER

221

Accordingly, two condensers *in parallel* with one another would be represented by 222, in which the two + terminals of the two condensers are joined, and the two − terminals are also joined together, making virtually one large condenser. If, for example, one had a capacity of 3 *microfarads* and the other 2 *microfarads*, the two in parallel would have a capacity of 5 *microfarads*.



IN PARALLEL

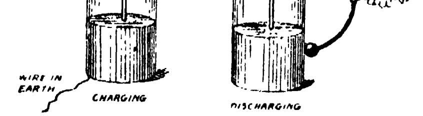
222

Fig. 223 represents two condensers joined *in series*, or, as it is sometimes called, *in cascade*. In this case the combination will act like a condenser of smaller capacity than either of them separately, for we have increased the total thickness in the amount of dielectric interposed across the circuit without adding to the area of either condenser. The equivalent capacity of the combination can be found by calculating the reciprocal of the sum of the reciprocals of the separate capacities. Thus, if the separate capacities of the two condensers are 2 and 3 *microfarads*, the joint capacity will be $1 \div (\frac{1}{2} + \frac{1}{3}) = 1 \div \frac{5}{6} = \frac{6}{5} = 1\frac{1}{5}$ *microfarads*.

IN SERIES

223

The Leyden Jar. It is more than a hundred years since the property of condensers was discovered, and the form which the apparatus received was that of a glass bottle or jar, coated inside and outside with a conducting coating. The very first Leyden jar with which electric shocks were obtained was a glass phial partly filled with water, while the moist skin of the hand which held it formed the outer coating. Later, these jars were made up in the form shown in 224, having inside each for convenience a metal rod, which passed down into the interior to touch the inner coating, and which was terminated at the top in a polished brass ball.



224

In old days these jars were charged by means of a *friction machine*, the sparks from which were sent into the brass knob, while the outer coating was connected to the earth. Such a jar cannot be charged if it stands on an insulating stand—for, as we have seen, in the act of charging as much electricity runs out of one coating as runs into the other. When a Leyden jar (or other condenser) has been charged, it can be discharged by connecting a conductor, such as a bent piece of wire, from the one coating to the other—that is, from the outer tin-foil to the knob. The instant that this is done the surplus from one surface rushes round to fill up the deficit at the other surface, there is a bright snapping spark, and the jar is discharged. If this discharge takes place through the human body a very unpleasant shock is the result.

Seat of the Charge. It was stated above that the seat of the electric charge is at the surface of the glass or other dielectric. The sheet-metal coatings are, in fact, mere conductors or electrodes that enable the electricity to flow to or from the surface whereon it is to rest as a charge. This is easily proved by taking a glass sheet and charging it by means of two loose sheets of tin-foil. If these are then carefully removed separately in such a way as not to make a circuit between them, it is found that they are not electrified. But if they are replaced, or if two other pieces of foil are placed upon the surfaces of the glass sheet, it will be found that the sheet will then give a spark when it is discharged.

Benjamin Franklin devised a dissectible Leyden jar, the metal covers of which could be taken off. With this he demonstrated that the charges reside on the glass, not on the metal coatings.

Energy of the Charge. It will, therefore, appear that the condenser does not really store any electricity, seeing that when being charged as much electricity runs away at the negative side as enters at the positive side. That which is stored in the condenser or Leyden jar is not electricity, but energy. Work has to be done in the process of charging, just as work has to be done upon a spring in the act of bending it. In the condenser as long as it remains charged, or in the spring as long as it remains bent, the work that has been done is stored up as potential energy, and afterwards that energy can be given out again. The condenser during discharge gives us back the electric energy that manifests itself by spark or shock. The bent spring during its recoil gives us back its energy as a visible motion. The energy given to the spring in bending it is equal to the product of the average bending force multiplied by the distance through which the spring has been bent at the place where the force is applied. This average force is equal to half the maximum force; hence, if f stands for the force and d for the displacement, the energy will be proportional to half $d\ f$. Similarly with the condenser: If Q represent the amount of electricity that has been displaced in or out during the charging, and V the electromotive force used in the charging, the energy of the charge will be represented by $\frac{1}{2}$ Q V.

Continued

Continued from page 3454

CENTRAL & SOUTHERN AFRICA

The Congo and Zambesi Basins. British Central Africa Protectorate. Portuguese East Africa. British South Africa. Cape to Cairo Railway. Islands

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

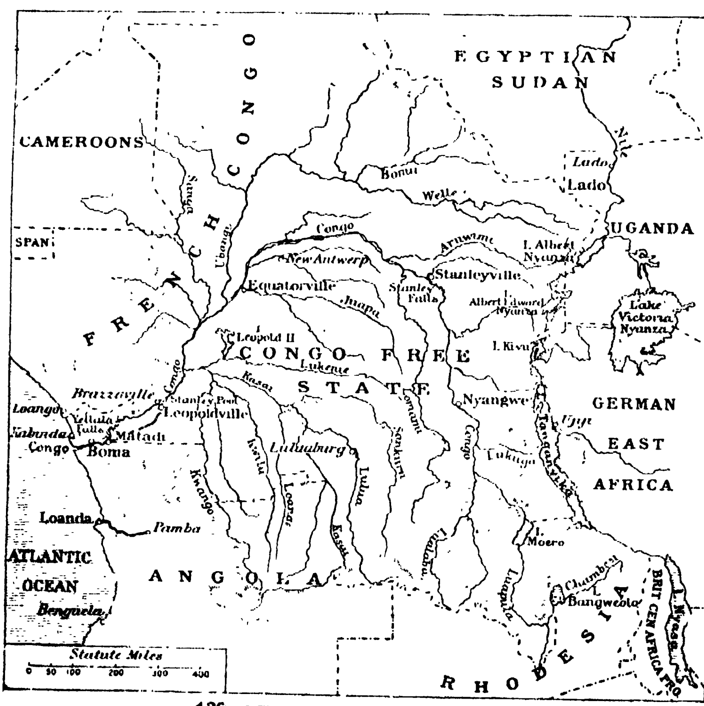
LAKE CHAD lies in a depression surrounded by higher ground, so that it has no outlet to the sea. It is a shallow, marshy lake, studded with many islands, and varies considerably in size in the wet and dry seasons.

The Cameroons and French Congo. Between the Niger and the Congo lie the German colony of the Cameroons and French Congo. The former rises from the steamy, swampy, mangrove-fringed, coastal plain to the grassy terraces of the plateau, reaching 12,500 ft. in the volcanic Cameroons Peak. The forests produce oil palms, rubber, kola nuts, ebony, etc. French Congo, which is broadly similar, extends north to the Sahara between Lake Chad and the frontiers of the Egyptian Sudan, and is continuous with the other African possessions of France.

The River Congo. The basin of the Congo (3,000 miles) occupies most of equatorial Africa [**130**]. Flowing through one of the rainiest regions in the world, the volume of water carried down to the sea by the main stream and its innumerable tributaries is enormous.

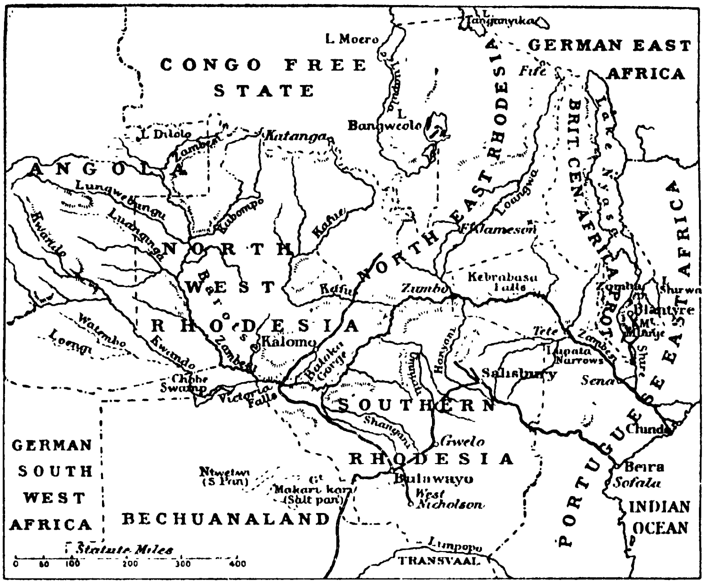
The Congo rises as the Chambesi in the mountains south of Lake Tanganyika, and is already a great river when it enters the swamps of Lake Bangweolo, from which it issues as the Luapula, a river as wide as the Thames at London. It now begins to descend, falling 1,200 ft. before it reaches Lake Moero. Still descending rapidly after issuing from that lake it receives the great Lualaba from the south. Not far below the confluence the Lukuga enters on the right, bringing down at certain seasons the surplus waters of Lake Tanganyika, the long, narrow rift valley lake to the east, lying nearly 3,000 ft. above the sea, in a deep chasm shut in by forested mountains. At Nyangwe, less than half-way to the sea, the Congo, which has received innumerable tributaries from the mountains, forests and lakes of the surrounding region, is a mile broad and still descending rapidly. Almost on the equator it forms Stanley Falls, a series of seven cataracts with open water between, extending over a distance of 56 miles. The Aruwimi, which has risen quite near the Nile, comes in from the east, flowing through densely forested country. Between the Aruwimi and the Welle, which rises near it, the country is inhabited by agricultural tribes, who have many villages in the forest clearings, surrounded by plantations of maize, banana, millet, tobacco, etc. The main stream is now enormous in breadth and volume, often breaking up into parallel channels, which extend over several miles of country. In some maps this part of its course is shown as a long, narrow lake.

Forest Scenery of the Congo. Sir H. M. Stanley has vividly described the dense equatorial forest through which this network of rivers flows. "Some of the islands seem to be aflame with crimson colouring, while the purple of the ipomæa and the gold and white of the jasmine diffuse a sweet fragrance. These islands are not mere things of beauty; the tall palms are perpetual fountains of sweet juice which,



130. THE BASIN OF THE CONGO

when effervescing, afford delight to man. The golden nuts of other trees furnish rich yellow fat, good enough for the kitchen of an epicure. The lengths of calamus are useful for flooring and verandah mats, for sun screens on river voyages, for fish nets and traps, for field baskets, market hampers, and especially for the construction of neat, strong houses and fancy lattice work. That pale white blossom is the caoutchouc. For the enterprising trader there is a ficus, with fleshy green leaves. Its bark is good for cloth, and its soft, spongy fibre will be used in the future for paper. Look at the various palms crowding on each other. Their fibres, prepared by the dexterous natives, will make the stoutest hawsers, the strength of which no fibre can match. See that soft pale-green moss draping those tree tops; that is the orchilla, from which a valuable dye is extracted. I need not speak of the woods, for the tall, dark forest on bank and isles seems to have no end."



131. THE BASIN OF THE ZAMBESI

The Lower Congo. Below Equatorville comes in the Welle, through similar forest country. The river gathers into a single narrower, deeper stream, and then widens out to the lake of Stanley Pool, shut in by white cliffs known as Dover Cliffs.

At the lower end of Stanley Pool, 1,100 ft. above the sea, the Congo begins its final rush down the last terraces of the plateau to the coastal plain. "It first precipitates itself with awful force down a five-mile slope, a succession of leaping waves, which from crest to crest might be about 300 ft. apart; then through a series of mad rapids, separated by short stretches of swift but steady flow, it is confined for 75 miles by the towering rock barriers of a cañon from 300 to 600 ft. below the level of the opposing summits of the cleft land; then for 88 miles it is tolerably safe for navigation; then comes another 60-mile rush, roaring cataracts alternating with noisy rapids, through the deep, rocky heart of the mountains, till finally the last plunge has been made down the Yellala Falls. A few miles below it leaves this sinuous and rocky gullet a navigable river for 110 miles, and flows by factories, villages, and towns to be presently vexed by the churning screws of ocean steamers." The current is too strong for the formation of a delta, and the Congo enters the sea by a broad estuary.

The Congo Free State. Politically, most of this region belongs to the Congo Free State (officially entitled the Independent State of the Congo), under Belgian control. Rubber, ivory, palm oil, and other tropical produce are collected by natives and brought to Leopoldville on Stanley Pool, the centre of the trade with the interior. It is the terminus of a line 250 miles long, built from Matadi, below which the river is navigable, to avoid the rapids of the Lower Congo. From Matadi the produce of the Free State is forwarded to Boma, 60 miles from the sea, which is in regular steamer communication with European ports.

The Zambesi. The Zambesi (1,600 miles) is the shortest of the great African rivers [131]. It rises at a height of nearly 5,000 ft. in the Dilolo swamps, which at certain seasons also feed affluents of the Congo. In its relatively short, steep course to the sea the Zambesi receives many tributaries, which should be looked out on the map. As it cuts its way down the terraces of the plateau it is broken up into rapids, narrows, and cataracts, many of imposing beauty. Between these obstructions are navigable stretches, where the land is flat and the river flows between low, reedy banks, inundating the surrounding country in flood. Such is the Barotse region of the upper Zambesi, a grass land on which cattle are kept in vast numbers. The valleys both of the tributaries and of the main stream are skirted on both sides by rich forest, and the many islands are also richly wooded. The finest of the many grand cataracts of the Zambesi are the famous Victoria Falls, the grandest in the world. Above the Falls the river is a noble stream over a mile wide, flowing between walls of forest. It plunges abruptly over a rocky ledge into an abyss over 400 ft. deep, with an indescribable volume of spray and a thunder of sound. It then flows for 40 miles through the narrow, zigzag Batoka gorge. Just below the Falls the river is crossed by the railway line from the Cape.

There are navigable stretches of considerable length between the Victoria Falls and the last of the Zambesi cataracts, the Kebrabasa Falls. Between these and the Lupata Narrows are large deposits of coal, which will before long be of commercial importance. At the Lupata Narrows the river contracts to 1,000 ft., flowing in a gorge between high rocky walls richly diversified with vegetation.

North-West and North-East Rhodesia lie to the north of the Zambesi, the lower course of which is through Portuguese territory.

The Shiré Highlands. 150 miles from the sea the Zambesi receives on its left bank its most important though not its largest tributary. This is the Shiré, from Lake Nyasa, another of the deep rift lakes of Central Africa. The middle course of the Shiré, like that of all African rivers from the plateau, is broken by falls and rapids, which interrupt navigation for 60 miles. It forms an important route from the Indian Ocean to the British Central Africa Protectorate and the north-east of North-Eastern Rhodesia, British territory which extends to the shores of Lake Tanganyika.

British Central Africa Protectorate. The highest parts of the plateau, which rises in the south-east to Mount Mlanje, 9,600 ft., are grass lands. Elsewhere the vegetation is tropical in character. All the most valuable products of tropical Africa, including rubber and the oil palm, are found. The chief crops cultivated by British planters are coffee—a native of the region, though the cultivated plant was introduced from the Botanical Gardens of Edinburgh by Scottish planters—cotton, and even wheat. The country, though not very healthy, is developing. Steamers run on Lakes Nyasa and Tanganyika. The largest settlement is Blantyre. The administrative capital is Zomba.

Portuguese East Africa. The lower Zambesi, some two or three miles broad, crosses Portuguese East Africa, an unhealthy region, exporting rubber and other forest produce. The delta, which begins 90 miles from the coast, is of the usual swampy character, subject to periodical floods, and held together by mangroves. The Chinde, with a port of the same name, is the only mouth practicable for large steamers. North of the delta is the territory of Mozambique, with a capital of the same name. South of the delta is the port of Beira, connected by rail with Salisbury and Bulawayo, on the Cape to Cairo line in process of construction. The busiest commercial town of Portuguese East Africa is Lorenço Marques, on Delagoa Bay.

Angola and German South-West Africa. South of the Congo the rainfall decreases rapidly, and the country gradually becomes an arid region, similar to that in the corresponding latitudes north of the Senegal.

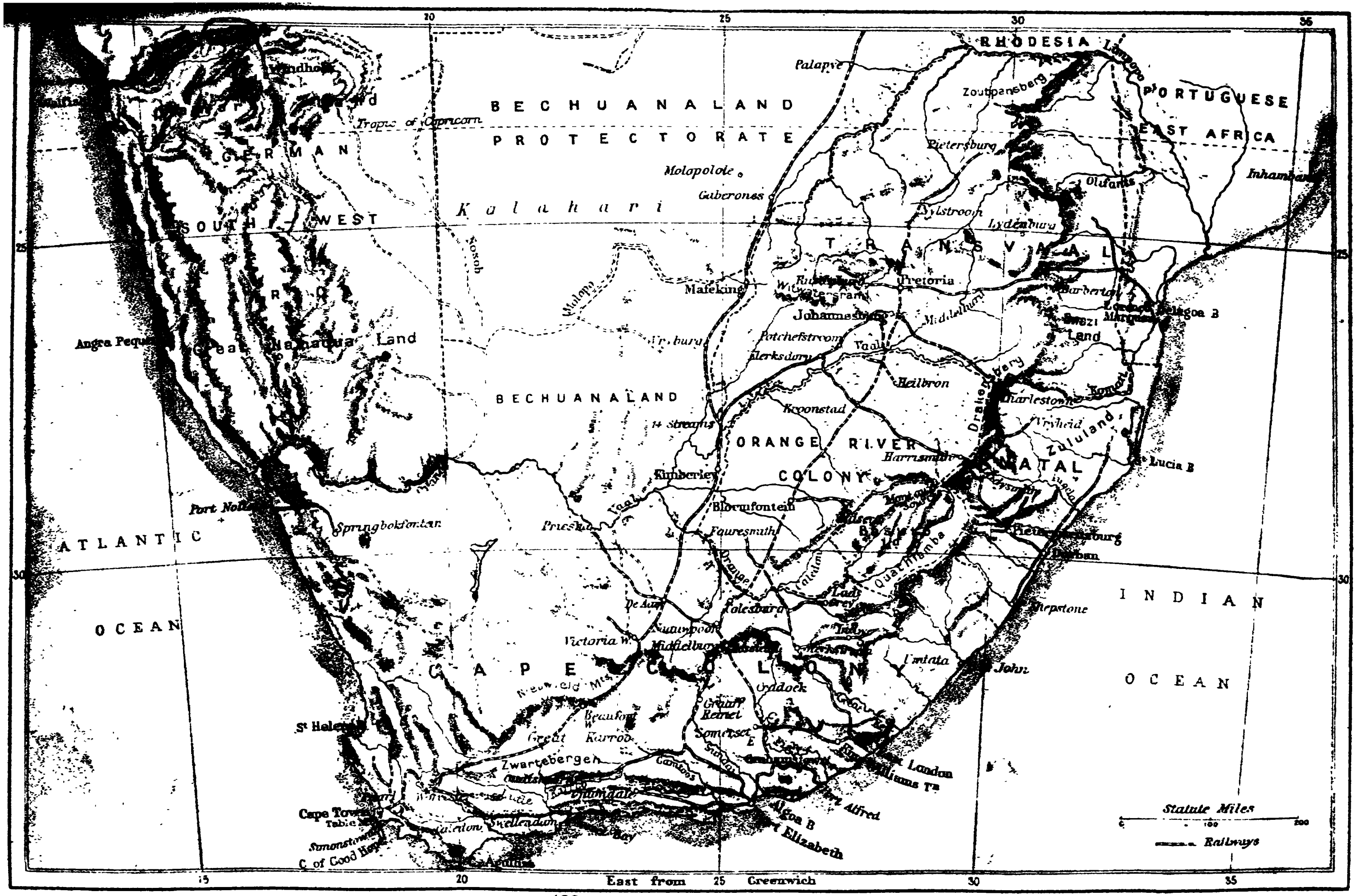
Angola, a Portuguese colony, rises from unhealthy coastal lowlands to the plateau, which is forested in the north, a savana in the centre, and arid in the south. Coffee is largely cultivated and exported from Ambriz, S. Paolo de Loanda, Benguela and Mossamedes.

German South-West Africa is an arid region of little economic value. The administrative centre is Windhoek, to which a line is built from Swakopmund near Walfish Bay.

British South Africa. The rest of Africa south of the Zambesi is British. It consists of Cape Colony in the south, Natal on the south-east coast, and inland the Orange River Colony, the Transvaal, the Bechuanaland Protectorate, Matabeleland, and Mashonaland.

South Africa consists of four well-marked regions—(1) A low coastal plain of varying width which is narrowest in the south-west, where the high rugged edge of the plateau comes down to the sea in Table Mountain, Cape Agulhas and other spurs. (2) Two series of ranges running parallel to the south coast, with the Little Karroo between them and the Great Karroo, beyond the inner ranges of the Zwartebergen. (3) Rising above the coastal plain and the Great Karroo the irregular margin of the plateau, which from below appears as continuous ranges of hills or mountains. The valleys which penetrate this margin grow narrower and steeper as the traveller ascends, and the spurs which enclose them become more mountainous in character. This high, irregular edge of the plateau is called the Drakenberg or Quathlamba Mountains in the south-east and east. Its finest scenery is in Basutoland, the Switzerland of South Africa, where Cape Colony, Natal, and the Orange River Colony meet. Here the land rises to 11,000 ft. in Mont aux Sources, from which flow the rivers Orange, Tugela, and a tributary of the Vaal. The precipitous edge of the plateau rises high above the undulating lowlands of Natal, and the rivers break their way down in cascades hundreds of feet high. (4) The immense interior tableland, flat or rolling, and diversified by isolated flat or pointed-topped hills or kopjes. It owes such beauty as it has to the sharpness and line of colour in the clear air, and to the wonderful atmospheric effects at dawn and sunset.

South African Rivers. South Africa lies in the lee of the trade winds in latitudes corresponding to those of the Sahara. Its climate is consequently very dry. Many rivers marked on the maps are dry except after rain, and fail to reach the sea. The longest river, the Orange-Vaal, from the Mont aux Sources, flows west to the Atlantic. The short Tugela from the same highlands, and the Limpopo, from the Witwatersrand of the Transvaal, flow east to the Indian Ocean. The Limpopo and Orange, though extremely shallow in the dry seasons, are never waterless, but their tributaries are often reduced to a string of pools. After rain they become impassable raging torrents for a few hours, to disappear almost as quickly. Add to this that all are obstructed by rapids in their descent from the plateau and flow in steep-sided valleys, and it will be seen that the rivers have contributed little to the opening up of the country.



132. BRITISH SOUTH AFRICA

F 28 G

Climate. If South Africa were as broad as North Africa it would be a desert like the latter. In the west, the Kalahari is actually a desert, though of less forbidding extent and character than the Sahara. Elsewhere the influence of the sea counteracts the aridity, and renders the rainfall over most of South Africa sufficient for stockkeeping; but the Karroos, shut in by mountain ranges, are very arid. In the south-west of Cape Colony the rain falls in winter, as in the Mediterranean, with which this part may be compared. Natal, like the east generally, has summer rains. The north-west is almost rainless. Everywhere the question of irrigation is important, especially for agriculture.

The proximity of the ocean reduces the summer heat of the marginal lands. Cape Town, in the latitude of Gibraltar, is cooler in summer and warmer in winter. On the tableland the range of temperature for the year and even for the day is great. The nights are cool for the greater part of the year. In the northern parts of the Transvaal, and in Rhodesia, the climate of the valleys is tropical, but the very high summer temperatures of the Sahara are never experienced.

Vegetation. The coastal plain is fairly well wooded, with small patches of primeval forest on the seaward slopes above. The higher part of the country is a vast area of grass land, passing into desert in the west, and into tropical forest in the valleys descending to the Limpopo and Zambesi. The few trees are thorny acacias or mimosas and eucalyptus trees introduced from Australia and found round most of the homesteads. After rain, the Karroos and veldt become beautifully green, but with prolonged drought the country takes on a brown and parched appearance. The vegetation of the Kalahari consists of thorny or succulent plants of the usual desert type.

The flowers of South Africa, and of the Cape Peninsula in particular, are extraordinarily beautiful. They include many heaths, and some of the loveliest ornaments of our conservatories.

The cultivated plants correspond with those of similar regions already described. In the areas of Cape Colony with winter rains, all Mediterranean plants are or might be grown. Maize, or "mealies," is the chief cereal everywhere in South Africa, but wheat is grown round the Cape and in the east of the Orange Colony. The production of wine is increasing. In Natal we find the products of monsoon lands. Tea is grown on the seaward slopes of the northern hills, and sugar, bananas, oranges, rice and tobacco are also cultivated. The Karroos and veldt are too dry for cultivation, except when irrigated, and are essentially a pastoral country.

Minerals. The mineral wealth of South Africa is enormous. The diamond mines of Kimberley, in Cape Colony, are the richest in the world. The deposits of gold in the Witwatersrand of the Transvaal are of incalculable value. Gold is also abundant in Rhodesia. The useful metals will become of more value as that of the gold and diamond mines decreases. Coal is found to some extent in all the colonies.

Occupations. At the present time the mining interest, helped by the introduction of indentured Chinese labour, is in the ascendant. It must, however, not be forgotten that mining tends ultimately to impoverish a country, not to enrich it. In its vast pasture lands South Africa has a more permanent source of wealth, and wool, hair and ostrich feathers may prove in the long run of more value than gold or diamonds. The veldt and Karroos are at present thinly settled, partly because the thinness of the covering of vegetation makes a great extent of pasture necessary. The future of agriculture is bound up with the question of irrigation. Manufactures hardly exist, and towns are few and small relatively to the vast area of the country. The chief disadvantages of South Africa are the dry climate, the absence of navigable rivers and timber, the scourge of locusts and the diseases of plants and animals, as well as the want of racial unity.

Peoples. Two kindred European races—the English and Dutch, both endowed with fine qualities, at present regard each other with suspicion. This is least marked in Cape Colony, where the mining interest is less prominent. Opposing economic interests, as everywhere else, count for more than community of race.

The native races of South Africa represent well-marked stages of economic development. The diminutive Bushmen depend chiefly on what Nature offers, and neither keep stock nor practise agriculture. The Hottentots are a pastoral people. The finest native race is the tall Kaffir, of Bantu stock, who possesses animals and practises agriculture. This race alone is likely to escape the destiny by which lower races disappear before the advance of the higher.

Cape Colony. This is our oldest South African Colony. It is chiefly pastoral, producing wool, hair, ostrich feathers, tobacco, and some wine and brandy. It has few good natural harbours, and no navigable rivers. Cape Town, the capital and chief port, is magnificently situated between mountains and the sea. Simonstown, in the vicinity, is a naval station. Port Elizabeth, on Algoa Bay, is built in a bare region, surrounded by low hills. East London is the port in this colony nearest the Transvaal, to which most of its imports go. Grahamstown is the chief inland centre in the east, and Kimberley, which owes its prosperity to the diamond mines, in the north.

Natal. Natal is more diversified in surface than Cape Colony, and has a hotter summer climate. The coastal regions are very fertile. There is a smaller proportion of waste land than in any other colony. Tea, coffee, bananas, and all manner of tropical produce are raised near the coast. Stockkeeping is the chief occupation up-country. Durban is the port, and Pietermaritzburg the capital. North of the Tugela, but included in Natal, is Zululand, containing some of the finest pasture land in South Africa and considerable stores of coal and gold.

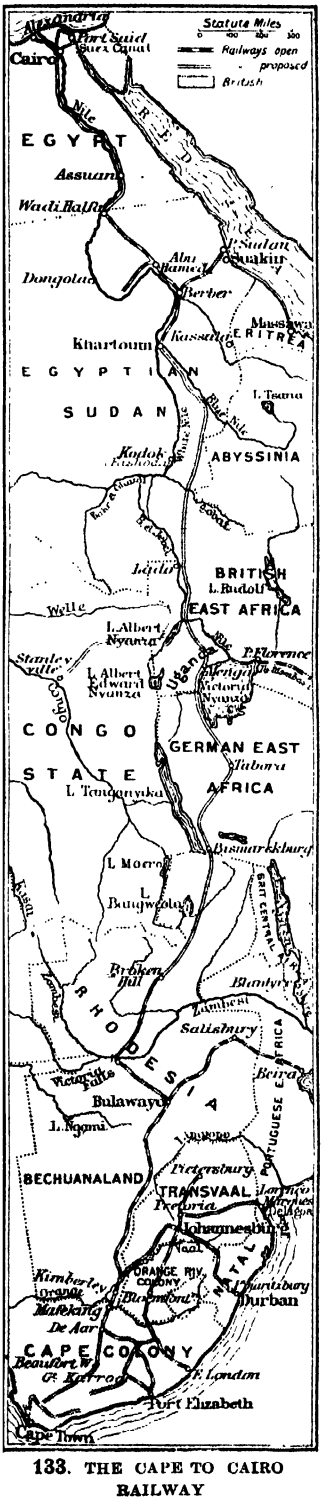
Orange River Colony. This is a grass land, engaged in cattle and sheep breeding, with agricultural land in the east, and diamond mines in the south-west. The only considerable town is Bloemfontein.

The Transvaal. The Transvaal is a grass land, with warm valleys opening to the Limpopo. These are well wooded, but unhealthy. Little land is yet under cultivation, though much is well suited to agriculture. Stockkeeping is the chief occupation on the thinly-peopled veldt, where the capital is Pretoria. The mining interest and dense population centres in Johannesburg, the largest and richest town, the middle of a belt of gold mines 50 miles long Coal is mined at several centres, and a rich diamond mine is exploited east of Pretoria.

Rhodesia. The greater part of Southern Rhodesia consists of undulating, grassy downs, or else low forest land, sinking to the dry Kalahari in the south-west, to the Limpopo in the south-east, and to the Zambesi in the north. Gold-bearing quartz reefs are numerous. Coal is mined at Wankie on the railway between Bulawayo and Victoria Falls.

The country is less dry than that to the south, as it lies in the belt of tropical summer rains. Below an altitude of 4,000 ft. fever is very prevalent. The development of the country is only beginning. The capital is Salisbury and the largest town is Bulawayo.

The Cape to Cairo Railway. In a country which has no navigable rivers, and where immense distances must be travelled through thinly-peopled and poorly-watered country, the construction of railways is essential to the development of the country. A line has been built from Cape Town to the Zambesi, and will in due time connect with the railways of Egypt and British East Africa [133]. It climbs by the valley of the Hex River to the Great Karroo, which it crosses to Beaufort West. It then ascends to the High Veldt, and reaches De Aar Junction, whence branches run to Port Elizabeth, East London, and through Bloemfontein and Johannesburg to Pretoria and to Durban. From Pretoria a line



133. THE CAPE TO CAIRO RAILWAY

runs to Lorenço Marques. From De Aar Junction the main line continues to Kimberley, to Fourteen Streams (where the direct line to Johannesburg now leaves it), to Mafeking, Bulawayo, and the Zambesi, and is now open to Broken Hill in North-West Rhodesia. From Bulawayo a branch goes by Salisbury to Beira, in Portuguese territory.

African Islands. The French island of Madagascar (230,000 sq. miles) is low in the west, and gradually rises to a plateau which is highest in the east and sinks in steep escarpments to the low eastern coastal plain, with its fringe of lagoons. The east has heavy summer rains, and is densely forested. The west is a much drier savana land. All forest products are important, especially rubber. Tropical produce of various kinds is cultivated on the plateau. The western savanas are inhabited by pastoral peoples. The mineral wealth is very great. Tamatave is the port, from which a railway is being built to Antananarivo, the capital, on the plateau.

Réunion (1,000 sq. miles) is also French. It is a beautiful volcanic island, richly wooded, and grows sugar, vanilla, coffee, and cacao on the plantations. The capital is St. Denis.

Mauritius (700 sq. miles), formerly the Isle de France, with its dependencies Rodriguez, the Admiralty Islands, the Seychelles, the Chagos Archipelago, and smaller islands, is a British possession. Mauritius is a volcanic island fringed with coral reefs. Port Louis, the capital, in the north-west, is the chief harbour, from which a railway runs across and almost round the island The sugar-cane is the most important crop, and coconut palms grow round the coasts. Two-thirds of the inhabitants are coolies from India, but negroes, Chinese, as well as French and English settlers, live on the island.

Off the west coast are the Azores, Madeira and Cape Verde Islands belonging to Portugal, the Canary Islands, with the fine Peak of Teneriffe, belonging to Spain; and St. Helena and Ascension, belonging to Britain. All are volcanic. The Canaries and Madeira are famous for their fruits, wines, and vegetables.

Continued

UNDERCLOTHING
continued from page 3475

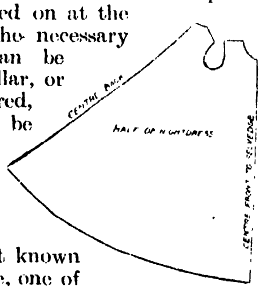
UNDERCLOTHING

Cutting Out and Making Camisoles, Underskirts, Bed-room Wear, Negligées, and Dressing-Jackets

By AZÉLINE LEWIS

FIG. **41** illustrates a French nightdress pattern, cut all in one, which is particularly comfortable for flannel, as it fits somewhat closely at the back. This shape can easily be evolved from a bodice drafting.

The centre-front is placed to the selvedge, so that there is a seam at front and back. A piece will have to be joined on at the lower part to make the necessary width. The neck can be finished off with a collar, or in any way preferred, whilst the sleeve can be the same as the foregoing. This pattern also forms an admirable one for a simple dressing-gown.



41. NIGHTDRESS CUT IN ONE

Lastly, we have that known as the "djibeh" shape, one of the later novelties, the idea of which was taken from the Turkish djibeh, which has no fastening, the garment being slipped on over the head [**42**]. This style, however, always requires a quantity of embroidery on the front, the back always being plain. Fig. **43** gives an idea of the shape.

42. DJIBEH

A to B is half entire chest measure; this pattern requires to be fairly roomy across the chest. A to C, half neck measure; A to D, one-third of same. The back neck is sloped down about 1 in.; C to E about 5 in., for shoulder; B to F, 8 in. Curve from E to F for front armhole. D to H, length of front; H to I, 28 in. for front lower edge. Slope and cut as shown, making back 2 in. less than front. The sides can be sloped out more if required.

The shoulder can be placed to the fold or tucked to back. The edge, of course, must be embroidered and the neck drawn in by means of ribbon passed through buttonholed slots, as marked in the diagram.

The sleeves should be cut rather wider at the wrist than the usual shape, and they are finished off and drawn up in the same way as the neck part.

For the drafting of an Empire yoke the worker should refer to TAILORING, cutting this, however, a little shorter.

For a nightdress of average size, 5 yd. to 6 yd. of 36-in. material must be allowed.

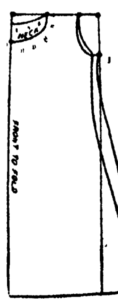
Camisoles. The shape, style, and making of the camisole, or underbodice, are legion, but all with the exception of **46** are based on the bodice pattern, which may be utilised with one, two, or more side pieces and darts. The various portions are usually joined by a flat seam stitched at each edge, but in the more expensive and elaborate bodices the seams are united by veining or beading.

Fig. **44** depicts a bodice of fine cambric in which all the seams are whipped and united in the manner above-mentioned, which has a very charming effect, but which should not be attempted by indifferent workers, as it is so easy to get the pattern out of shape.

Fig. **45** gives an American shape, the charm of which is that it requires no fastenings. It can be cut from the bodice pattern, as shown by the broken line, the front being extended from the shoulder into a point at the waist, this point depending on the size of waist, as it only needs to extend beyond the under-arm seam. The making of this corset-cover is a very simple matter, and the trimming can be added according to taste.

Fig. **46** illustrates a drafting of a bodice cut all in one, in which the front seam comes on the cross. This, however, is a pattern better suited to slight than stout figures. It is made with or without an added basque, as preferred. For the drafting, take a piece of paper $1\frac{1}{2}$ times the length of back, and wider than half of chest measurement, and fold it in half. Divide length into three parts, mark them respectively A, B, and C, and rule lines at right angles. C to D, quarter of waist measure; B to E, half chest measure. Rule a line from D through E to F. Fold paper at this line and mark G exactly under A. Open out again, draw a line from F to G, and mark A to H one-sixth of neck. Curve down $\frac{1}{2}$ in. for back neck.

G to J, quarter of neck measure; draw line from H to J. B to I, half chest; draw line from G to I. G to K, quarter of neck; curve from J to K for front neck. Extend I to L for length of front; measure C to L, half of waist, and finish front. M is midway between C—L and D. Curve as shown by the broken line.



43. DJIBEH DRAFTING

J to P, 4 in. to 5 in., as required for length of shoulder. H to O, the same. Lower the latter, raise the former $\frac{1}{2}$ in., and draw shoulder lines. M to N, length of underarm; curve from O and P to the point for armhole, as shown, hollowing out front a little more than back.

For the basque, see Knickers

in Fig. 30, or cut to the same as the lower portion of bodice just drafted, making it a little larger. If tucks be required, extend fronts from K to L, the needed amount.

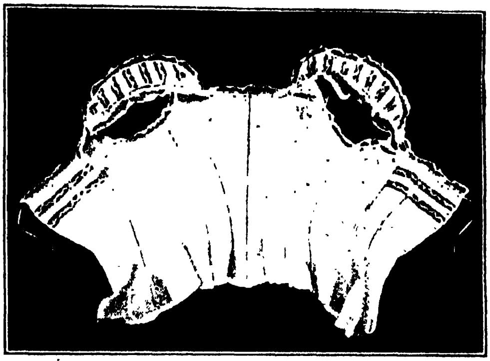
The sleeve can be any shape desired.

Many camisoles are made with full or tucked fronts, without darts, and for evening wear the shoulder straps are either of insertion and lace or ribbon, whilst very dainty corset-covers have been made from two hemstitched pockethandkerchiefs. These, however, are all fancy affairs, which the maker can easily evolve from a design or imagination.

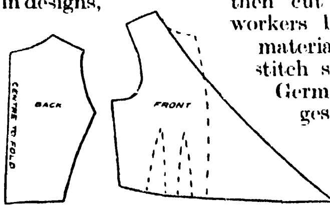
Embroidery now forms, in many cases, the sole decorative finish of the more elaborate camisoles, the fronts being ornamented in some pretty design worked in satin stitch, and the edge in buttonholed scollops, small slots being worked at intervals to pass the ribbon through. For such bodices, fine linen is generally used.

Transparent insertions arranged in designs, with and without tucked centres, also form an important part of fine trimmed underwear. The insertion must first be tacked on the garment in the required design, care being taken to keep the two sides exactly even, and to tack it fairly closely at each edge. Various stitches and methods are employed in the working of such trimming, so no hard-and-fast rule can be given. In the cheaper forms the insertion is merely stitched at each edge, and then cut away on the wrong side. This, however, is not satisfactory for fine goods, as the edges soon pull and fray away from the insertion and quite spoil the look of the garment.

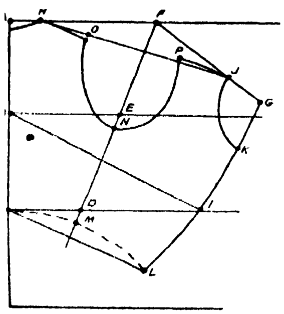
When the insertion is tacked on the right side, cut the material through the centre of the design on the wrong side (using short, blunt-pointed scissors), snipping well any curves to make these set well, as in embroidery, then turn down the cut portion to the edge of the insertion on the wrong side, and oversew firmly and very closely together on the right side. In some of the Irish work the two edges are sewn together by means of satin stitch, forming a raised edge, and then cut away afterwards. Again, some workers buttonhole the edges of insertion material, whilst others unite the two by stitch somewhat similar to that in the German seam, and others whip the ges on the wrong side. The method, however, is not important, provided the result be neat and strong, and the above directions give as good a result as any. Use very fine embroidery cotton or Harris's lace thread, No. 80 or 100, the latter being excellent for the purpose. Fig. 47 shows the method above-described for transparent insertions: (*a*) the insertion sewn on and material cut through on wrong side; (*b*) the insertion sewn on and edges neatened.



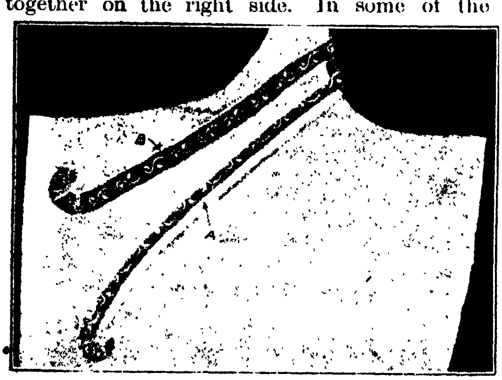
44. CAMISOLE WITH VEINED SEAMS



45. CROSSOVER CAMISOLE



46. UNDERBODICE CUT IN ONE



47. TRANSPARENT INSERTION

From ½ yd. (or less) to 1½ yd. of 36-in. material is usually required for a corset-cover.

Petticoats. As the majority of petticoats are now cut on the lines of a good skirt, being either 3 or 5 piece affairs, we have only included the drafting of a plain gored one intended for flannel, but hich can be easily lengthened or have a flounce added for an underskirt.

Front Width. A to B, one-sixth of waist; A to C, 1½ in.; C to D, length, plus 4 in. (giving two tucks 1 in. deep) for tucks and 2 in. for hem; B to E, ½ in. more than C to D.

Side Gore. A to B, half of waist, less 2 in.; A C, one-twelfth of waist measure; C to D corresponds with B to E of front width, and B to E the same

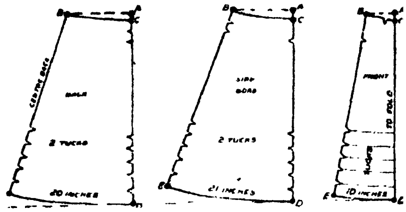
Back Gore. A to B, half of waist, plus 1 in.; C to D and B to E are the same as in the preceding gores [48].

Yoke Band. See Diagram 30, making it, however, a little more pointed in front.

This petticoat, if made of flannel, must have the seams herringboned, whilst the lower edge can be festooned [21], or it can be finished off with a lace or scolloped frill, or one composed of lace and ribbon.

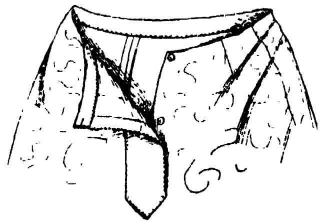
For the drafting of other gored skirts, see DRESSMAKING, also for the shaped flounce, if this be desired.

Princess Pattern. This can be drafted from a bodice and skirt, but full directions for the drafting of a Princess dress are given in TAILORING, which can be simplified for a petticoat—*i.e.*, made with only one side piece, also shorter and less full.



48. GORED FLANNEL PETTICOAT

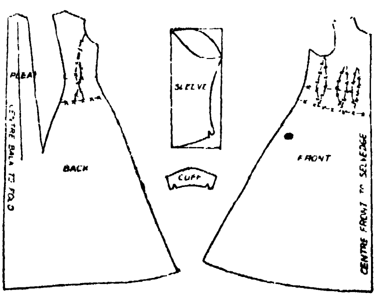
Many jupons are now made with top of closely-fitting material and removable flounces, the latter being secured to the foundation by buttons and buttonholes, or by ribbon passed through slots in both flounces and foundation. For the slots, see CHILDREN'S CLOTHING.



49. WAISTBAND OF PETTICOAT

Fig 49 illustrates the method of finishing off the waist part and placket-opening of an ordinary petticoat. The strip for neatening the waist must be cut on the cross to set well. In some cases, this is piped to make it stronger, but the cord must be very fine or it will make a ridge.

The average quantities for petticoat 3 yd. of flannel, and 4 yd. to 6 yd. of 30-in. goods for underskirt, with one or two plain frills, but elaborate silk one will need 7 yd. to 9 yd. In calculating for such petticoats, the necessary quantities of which vary very much, it may be some guide to reckon 3 yds. of 30-in. material for the upper part, and then add on what may be required for the flounces. Directions for calculating the quantities were given in DRESSMAKING.

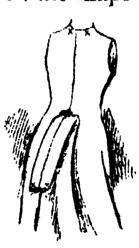


50. WATTEAU DRESSING-GOWN

Bed-room Wear and Negligées. Under this heading we may include dressing and bed jackets, and various styles of morning and dressing gowns.

As in all other classes of garments, the shape and variety is infinite, and it would be impossible to deal with all, but the student who has followed the course should be able to construct any design she wishes by the aid of the diagrams given and a bodice pattern.

As the dressing-gown with a Watteau pleat at back is always more or less a popular shape, we have selected this as an example.



51. WATTEAU PLEAT

52. COMBING WRAP

No. 50 gives the diagram, which, as will be seen from the broken lines, is cut from the bodice pattern, the pleat being added at the back, as well as the required length from the waist. The broken lines and crosses indicate the portions which are not to be cut out.

The sleeves, of course, can be made of the prevailing shape, and if a double-breasted garment be desired, extend the right front as much as may be liked beyond the fold of centre, which should be carefully marked.

The Watteau pleat should have the two edges carefully seamed up on the wrong side, opened and pressed, and then be turned inside out like a bag, and pressed with the seam even with the centre fold.

No. 51 shows the pleat made and ready to be secured to the back neck, as shown by the two crosses, when it will be sewn in with the neck-band or collar. It should be drawn a shade tight, *i.e.*, not allowed to hang slack, which will keep the pleat out well in the shape at the lower part; but, of course, it must not drag in any way. For such a gown, 4 yd. to 5 yd. of 44-in. goods will be needed, without turnings.

A yoke dressing-gown can be cut on similar lines to the night-dress shown in Diagram 40, allowing, of course, extra fulness at front and back, and sloping out the side seams. The neck of yoke may be rounded if wished, or it may, of course, be made in pointed style, whilst for the cutting of an American yoke full directions were given in DRESSMAKING.

A "Kimono" shape can be evolved from No. 50 by making the fronts a little wider and sloping off from the shoulder to about the waist part. The back may be shaped slightly, but the garment beloved in the Land of the Rising Sun is innocent of any shaping and fulness.

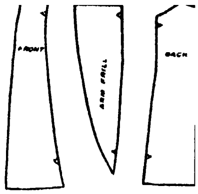
Tea-gowns. The tea-gown forms a class in which elaboration and trimmings have quite put into the shade its original idea and meaning of a simple, loosely-fitting robe to be donned in the intimacy of one's private circle.

The Empire yoke and style makes up very charmingly for such gowns, and is capable of much ornamentation. For the drafting of an Empire yoke or bodice see TAILORING, where full directions are given. The skirt part may also be cut as there shown, adding on the length and fulness required.

If the skirt part be preferred gathered at the top, all that is necessary is to add some inches more at centre back and front.

This style will form an exceptionally graceful gown with the neck part finished off with a fichu of soft silk, net, lace or muslin, and frilled elbow sleeves, whilst one or more frills could finish off the skirt edge. For other and more elaborate styles, the worker should consult the current fashion papers.

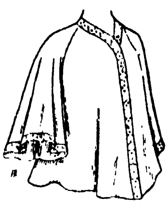
Dressing Jackets. Here again the variety in make and style is infinite, but the majority of dressing jackets are made either in sacque or yoke form, with or without collars, as preferred, and these, we think, the worker will be able to manage for herself with the aid of the preceding diagrams and explanations. We have, however, in **52** selected a combing wrap of charming simplicity of make and arrangement, capable of being made into either a fascinating shoulder covering and adornment, or as an addition to the wardrobe for indoor wear.



53. COMBING WRAP

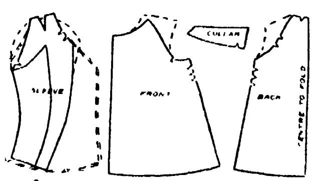
As will be seen, it consists of three parts—front, back, and armhole frill—the latter taking the place of sleeves, as the sides are open and the garment is merely passed over the shoulders [**53**].

For a combing wrap, cambric, muslin, or flannel can be employed; but for the second-named purpose, oriental-patterned silk would be the most suitable, edged with a fold of plain cross-cut silk, satin, or velvet. About 2 yd. of 36-in. material should suffice for this wrap, in which there are only two seams and no fastenings.



54. DRESSING SACQUE

Diagram **55** gives a drafting of a jacket, either for combing purposes or for invalid use, ' armhole seams extending to the neck, which makes for ease in slipping on, an important matter in the case of invalids. If necessary, the jacket need not be joined at the underseams, but only at the armholes to the neck, so that it can be slipped round the shoulders and fastened by buttons and buttonholes or ribbons, the sleeves being drawn up like those of the "djibeh" style, or left loose [**54**].



55. DRAFTING OF DRESSING SACQUE

The broken lines show the variation in this pattern from the ordinary shape, so that it could be cut like the other garments from a bodice pattern. By following these broken outlines the ordinary sacque shape would be obtained, but for elderly people or invalid use the Raglan shape (shown by the firm line) is infinitely preferable. The double broken lines show the full sleeve sketched; the thick line the plain Raglan sleeve, which is better for invalid use. If made of cambric, the seams should be of the French variety, but if of flannel they must be herringboned down quite flat. About 2 yd. of 36-in. material will be required for this jacket.

An excellent shape for an invalid night-dress is the "djibeh" shape, made to fit closely at the neck and fastened at the shoulder, the upper part of sleeve level with this being left open and fastened when on by buttons and buttonholes, or tapes and ribbons. If necessary, one side seam could also be arranged to fasten in the same way [**42** and **43**].

As it has already been pointed out, the whole beauty of this class of work depends upon the fineness and excellence of the needlework. It is practically impossible for an indifferent worker to produce dainty and attractive lingerie.

Underclothing concluded

Group 16 FOOD SUPPLY 4 Continued from page 3385	

Continued from page 3385

BISCUIT MAKING

How the Materials Used are Prepared. Shaping and Baking Wafers and Confectionery. Ship and Dog Biscuits

By CLAYTON BEADLE and HENRY P. STEVENS

THE dainty and attractive articles of food called biscuits, in the form in which they are known to-day, are essentially modern innovations, and the industry connected with their introduction and also of the machinery necessary for their manufacture are essentially English.

The Biscuit Industry. The term *biscuit*, spelt in various ways, can, however, be traced back for many centuries. The origin of the name, according to Gibbon, the historian, has reference to the practice of twice baking bread in a special manner when it was required for very long voyages, or for military campaigns.

The method of baking the goods as indicated by the name has not, however, been preserved to any large extent. Some few well-known biscuits, notably the *rusks* of various kinds, are still twice baked. The only other instance of a double treatment in cooking is in the case of *cracknel* biscuits, where the material is first boiled and then baked.

Previous to about 1830, biscuits of a certain character had been known and were appreciated amongst the élite of society. These biscuits, however, having to be made entirely by hand, were comparatively high in price and were consequently the luxury of the few. The introduction of machinery, with the consequent enormous increase of production, together with free import of the raw materials necessary for biscuit manufacture, have contributed to the popularity and cheapening of these articles of diet.

Machinery. Biscuit-making machinery is in its essence but an application of the old world method of mixing flour and other ingredients into a dough, rolling it out, cutting it into shapes, and baking it. Some modifications have been made in the machinery from time to time, but possibly in no other industry have fewer alterations been made; in fact, in the works of Messrs. Peek, Frean, who have been good enough to give us the benefit of their opinion on many important points, are many machines which have been in continuous use for thirty years or more. They are doing as good work now as when first introduced, and could not be improved upon by any machines of more recent make.

In the dry store-room of a large biscuit works, which may be regarded as the starting point, certain raw materials, such as eggs, coconuts, almonds, raisins, sultanas, and currants, are sorted and freed from dirt, stalks, husks, etc.; to some of these we will make detailed reference.

Eggs. In a large factory some hundreds of tons of eggs are used in the course of a year, 100 eggs weighing from 16 lb. to 18 lb. When proper care is exercised, each egg is broken individually by hand, just as a cook breaks an egg on the side of a basin. After each has been examined to see that it is quite fresh, the yolk and white are thrown together into gallon pans. Each gallon is then further tested by an overseer to see that no musty eggs have been overlooked by the girls whose work it is to test them. One musty egg would spoil a whole mixing, hence the necessity of examining every egg. The mixed white and yoke is then passed through a sieve to remove any particles of egg-shell, etc., into a whisk holding two gallons, when, after whisking, it is ready for use. The egg-shells are burnt as they are useless. Attempts have been made to utilise the albumen adhering to the egg-shells, but without success, on account of the attached dirt contaminating the extracted albumen. Such extracted albumen, although unfit for human food, might find useful application in other directions. When the yolks and whites have to be separated, large eggs, such as turkey eggs, are, by preference, used. This separation is done by hand, exactly as a cook does it—namely, by breaking the shell and tipping the yolk from one shell to another, in such a way as to allow the white to run off into a basin. The yolk is used for rich cakes, and the white for such goods as macaroons, while the whole egg is used for ordinary qualities of biscuits.

Milk. Milk is also used to a very large extent, and to ensure its absolute purity, every delivery is examined by the resident analytical chemist.

Coconut. Coconut from which the oil has been extracted before shipment, by means of pressure after grinding, arrives at the works firmly pressed into wooden tin-lined cases. The agglomerated lumps are broken up and passed through automatic shaking sieves of different meshes, so as to separate it into three different grades of fineness to be used for different kinds of biscuits.

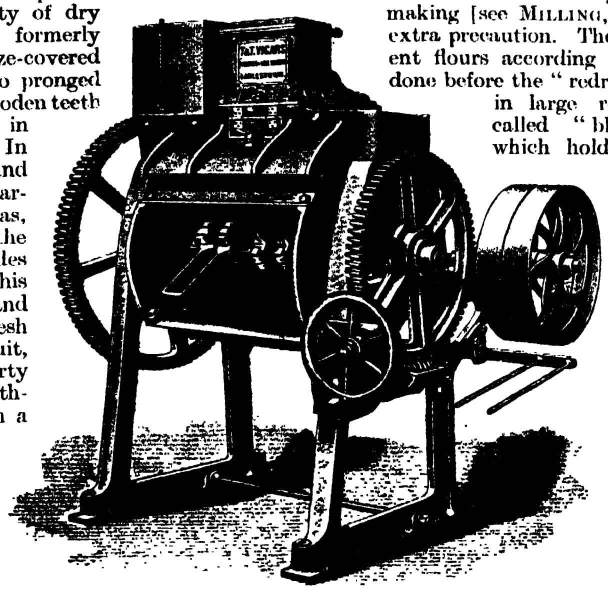
Almonds. Almonds are first filled into a large basket of wire gauze and plunged for five minutes into a cauldron of boiling water. After removal they are fed on to a travelling belt, which carries them to a chute and drops them between a pair of rubber rollers, set just the right distance apart to squeeze the almonds so as to make them jump out of their husks as can be done between the finger and thumb. They then pass through a pair of wooden rollers to remove those husks which have escaped the first pair. The skinned almonds then fall on to a tray, while the husks, being comparatively light, are winnowed by means of a fan in the opposite direction. The almonds are then hand-picked to remove any husk still adhering, and then dried at a temperature

of 100° F. The manner of slicing now to be employed will depend upon the purpose for which the almonds are to be used—whether for flavouring or for ornamenting cakes, etc. They can be either cut crossways, lengthwise, or cut or split along the seam in the narrow or broad way of the almond, or merely ground up. The cutting machine consists of a wheel which revolves against fixed knives passing into grooves in the wheel. This wheel is fitted with numerous recesses, into which the almonds are fed by hand while it revolves. The cut almonds drop into boxes beneath. When used for confectionery, the almonds are not husked, as the presence of the husk in the cakes is beneficial, giving a peculiar and agreeable flavour. Such almonds are largely obtained from Majorca and Valencia.

Sultanas. Sultanas arrive at the works pressed together in cakes; the cakes are broken up and the separated sultanas mixed with a small quantity of dry flour. They were formerly "dressed" in a gauze-covered trough, in which two pronged stirrers fitted with wooden teeth moved to and fro in opposite directions. In this way the flour and stalks, etc., were separated from the sultanas, and fell through the wire bottom and sides of the machine. This flour was used over and over again for fresh quantities of fruit, until it became too dirty for further use. Without admixture with a dry substance, such as flour, it was not possible to remove mechanically these impurities on account of the sticky nature of the sultanas. They were then hand-picked and sorted to free them from any stones which may not have been removed in the husking machine. This was done by girls, who passed the sultanas over a tray covered with perforated zinc, when any stones present were detected by grating on the metallic surface. This elaborate process was considered necessary to completely cleanse the fruit, and to ensure that no gritty matter or impurities found their way into the confectionery.

Currants. These come into the works in cases, half cases and quarter cases, containing 1 cwt., 56 lb. and 30 lb. respectively. The modus operandi, until recently, was to fill them into a "dresser" consisting of a slowly revolving cylinder covered with fine parallel wires, inside which a brush revolved. The currants travelled down this wire into a second "dresser," while the stalks, which were removed by this treatment, fell through the wire. In the second dresser the currants met with a jet of water, whereby they were thoroughly washed, and then passed on to a rocking sieve which struck the surface of water with a peculiar oscillatory motion, that caused the currants to travel forward, but deposited the stones, which fell between the crevices, and the dirt between the wire meshes. The currants were then dried by means of a centrifuge.

As a simplification of the above, sultanas and currants are now washed in the same machine. The cleaning is done in a semicircular sieve suspended in a tank of water, through which the beaters work backwards and forwards and thoroughly remove the dirt; the semicircular sieve is then tipped up and the contents dropped into a centrifuge.



1. BRAKE MACHINE (T. & T. Vicars)

Flour. Flour as received from the millers is "redressed" before being used for biscuit making [see MILLING, page 3078], as an extra precaution. The blending of different flours according to requirements is done before the "redressing," sometimes in large revolving cylinders called "blenders," each of which holds the contents of about ten sacks of flour. The most up-to-date flour-blending machine consists of a fixed cylinder [see 12, page 3395], round the bottom of which a revolving knife moves and cuts off an equal quantity from each of the compartments into which the cylinder is divided. The blending and sifting of the flour is then continued. The redressed and blended flour is then taken to the mixing-room to be made into dough.

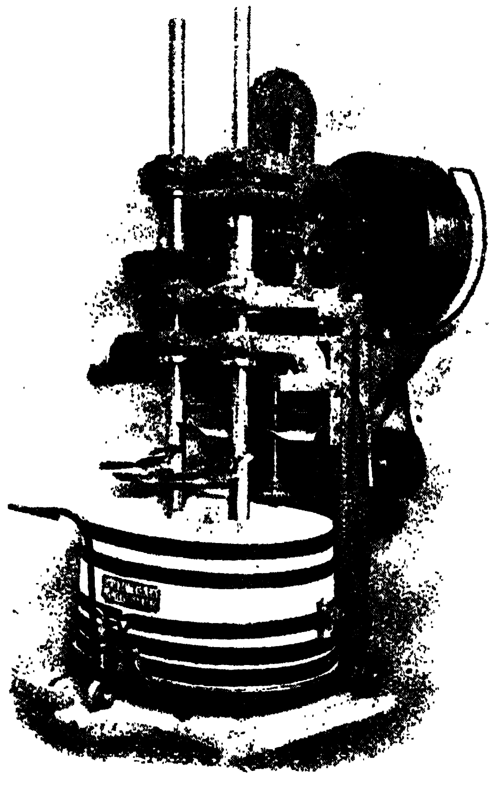
The Mixing-room. In this department the major ingredients of the different biscuits are weighed, measured, and mixed. The flour, sugar, etc., are filled into large hoppers capable of holding two bags of flour besides the other ingredients. When the hopper is full, a trap in the bottom is raised by means of a cord, and the contents shot down into *drum mixers* situated in the room below, where the liquid ingredients, such as milk or water, are added. The mixers [1] consist of iron drums through which a square shaft passes. This shaft is provided with arms in the shape of loops. These, however, get worn to a sharp edge by constant friction. When the drum has been filled with the charge, a large cover is drawn up over the "man-hole" by means of a hand wheel. The agitator is then made to revolve

until the mixing, which takes an hour, more or less, according to the constituents, is complete. The contents of the mixer are then emptied into a wooden truck. There is another form of mixer called a *soft dough mixer* [2]. This consists of two vertical shafts side by side and fitted with blades disposed in corkscrew fashion. These shafts revolve in the same direction, and thus give the dough a grinding and thorough kneading. The dough to be mixed is filled into large wooden tubs, which are then run underneath the mixer, the knives of which are lowered and set revolving.

Rolling. The machine-room and bakehouse comprise the department in which the actual making of the biscuit takes place. The dough is first put through the *brake,* which consists of an endless felt travelling between two iron rollers [3]. The motion of the rollers can be reversed by means of gearing, and the roll can be raised or lowered by means of a hand wheel. On this machine the dough is rolled into a sheet of any desired thickness by being made to pass to and fro under the roll, which is gradually lowered. The dough is kept well dusted with flour to prevent it sticking to the roll.

The dough is next taken to the *cutting machine,* of which the latest type is shown in 4. It is placed on an endless travelling felt, and dusted over with flour to prevent it sticking to a roll under which it next passes. There are usually two pairs of these rolls, the first of which presses the dough to, say, twice the thickness required for the biscuit, and the second to the actual thickness. The practice of brushing or spreading the flour with light brushes by hand has been superseded by a revolving brush.

Cutters. The dough then passes on to another endless felt [4, far end], which moves forward in jerks, and in this way is carried under the cutters which stamp the shape of the biscuit out of the dough. The number of biscuits stamped out at one operation varies from 6 to 80, according to size. The "scrap"—namely, that portion of the sheet of dough between the cut biscuits—passes on to a separate felt up over a roll, whence it is caught on a tray, taken back to the "brake," and used again. The biscuits deprived of their scrap are conveyed on the felt, whence they are transferred to travelling iron trays carried under the felt on chains. The biscuits fall in regular lines on to these trays, and if for any reason a row of biscuits has to be removed from the felt, the motion of the tray can be arrested till the next row is ready to fall on to it, when it is allowed to proceed. If this were not done the trays would not receive a regular charge, and consequently the biscuits would not be evenly baked in the oven.



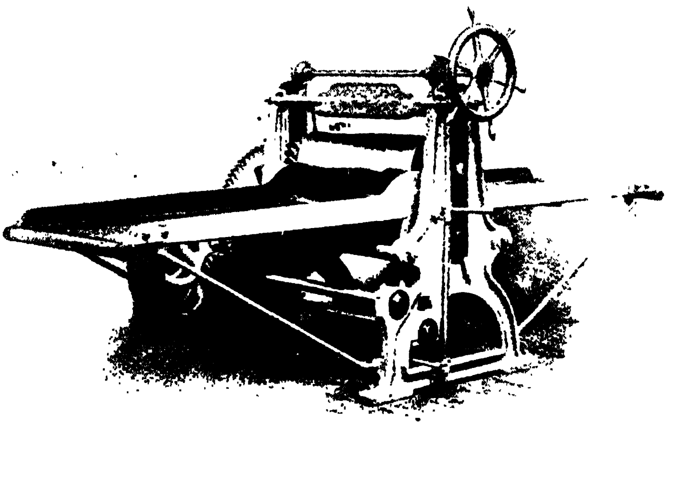
2. SOFT DOUGH MIXER (J. Baker & Sons, Ltd., Willesden)

Spraying. In certain cases, as with ginger nuts, each tray, as it is filled, is lifted off and passed by means of a band under a hood, where the atmosphere is charged with a fine spray of water. Biscuits so sprayed are seen to possess a fine film of moisture on their surface, which imparts to the biscuits a gloss when baked. From this machine the trays of biscuits pass through the ovens.

The Ovens. The trays are now laid on travelling chains provided at equal intervals with spikes that catch the edge of each tray and carry it forward through the oven at a uniform speed, which can be regulated to suit the baking. The ovens are now constructed 50 ft. long, and are heated by producer gas generated in the works [5]. The time taken by the trays to pass through the oven varies with the class of biscuit. With ginger nuts, the time is about twenty-five minutes. With this particular kind of biscuit, one cutting machine supplies two ovens and turns out about 85 cwt. per diem. Each tray takes 84 ginger nuts.

Sugaring. Biscuits are sugared from a long rectangular box which stretches the whole width of the machine. The box is mechanically shaken up and down, causing the sugar to

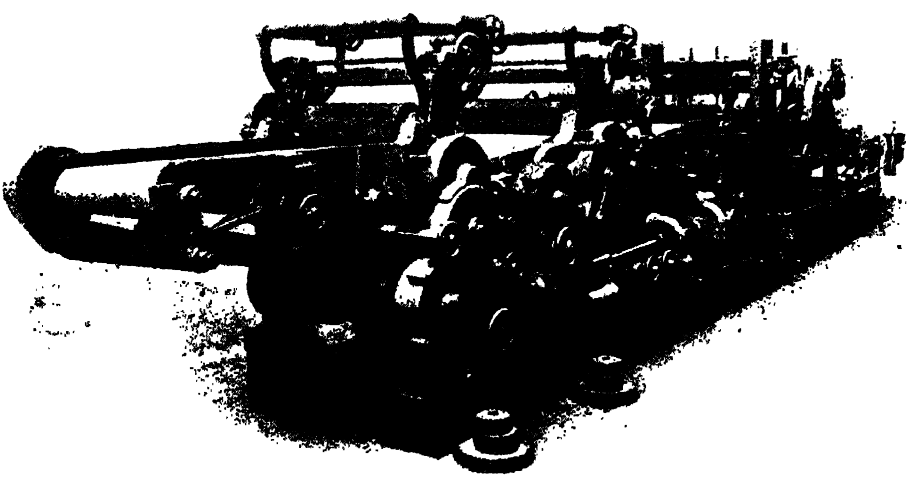
fall through in a regular shower on to the dough passing under it. Biscuit fingers are made and cut out much like ordinary biscuits, but they are carried off on wire trays instead of on the ordinary iron ones. As they leave the cutter they are thin, but slightly rounded on the top and nearly flat underneath, so that when baked the expansion of the upper surface causes them to curl up and to assume the shape of a spill. A somewhat peculiar process is in the above instance ingeniously made use of to assist in forming the biscuit into shape.



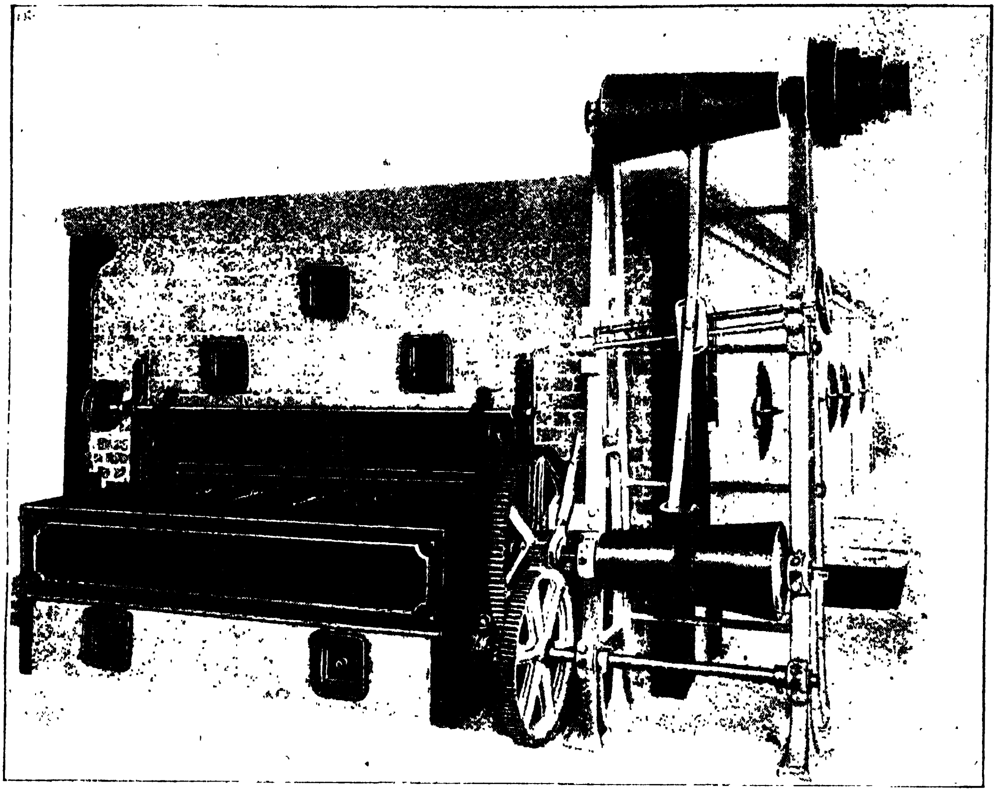
3. HARD DOUGH BRAKE (J. Baker & Sons, Ltd.)

Chocolate Fingers. Biscuit fingers are sometimes coated with chocolate by hand. They are laid on wire trays divided into partitions into which they fit. Each tray holds twelve. The trays are then dipped into liquid chocolate, and immediately on removal briskly shaken to remove any excess. By inverting the trays, the fingers fall on to sheets of paper, on which they are conveyed to the racks for drying. These processes are now performed mechanically. Chocolate should be stored at constant temperature, otherwise it gets streaky. The temperature of the store-room in which this class of goods is kept is maintained at about 70° F., to prevent the chocolate from "streaking off." The temperature should never rise above this. The chocolate used for confectionery, such as *fingers* or *wafers*, is prepared by mixing pure chocolate with a small amount of *cocoa butter* in the proportion of about 1 cwt. of chocolate to 20 lb. of cocoa butter.

The "Vanessa" biscuit is prepared on a machine somewhat on the following lines: After the two colours of dough, one white and the other chocolate, are put into the hoppers, plungers which work between the hoppers are raised and lowered by means of cams, and force exactly the right amount of batter to the



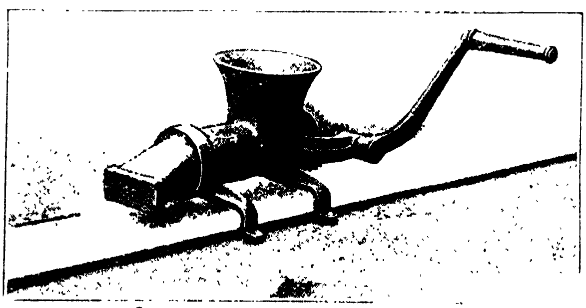
4. HARD AND SOFT DOUGH GAUGING, CUTTING, STAMPING, AND PANNING MACHINE (J. Baker & Sons, Ltd.)



5. TWO-PAN TRAVELLING OR CHAIN OVEN (J. Baker & Sons, Ltd.)

trays which pass underneath. The white and chocolate coloured doughs are pumped simultaneously upon the pan.

Fairy Cakes. Here the dough is deposited, in rows, from a similar machine to the above, on to a "spun pan," which consists of a tin plate in which a number of small hollows have been shaped out by an ingenious process of "spinning" (hence its name). Each of these numerous hollows provides a mould for a fairy cake. The pans are smeared with a mixture of butter and flour to prevent the baked cakes from sticking. When the pans have been used, they are cleansed by being pressed against revolving brushes moistened with water, and after smearing with butter and flour, are ready for further use. With the "drop machine" there is no waste or scrap, as the exact amount of stuff required is delivered for each biscuit or cake.

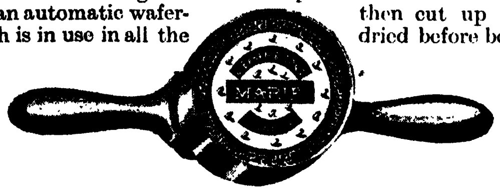


6. CONTINUOUS BISCUIT FORCER

Colonial Biscuits. Colonial biscuits are made from dough on the "Rout" press. In a similar manner are produced "Cable" and "Twist" biscuits, and, with special "dies," the "Rose, "Café," "Ring," and similar biscuits. Colonials are formed in strips about ¾ in. wide, and have a rough upper surface, caused by the rucking up of the surface as it passes from the die of the nozzle. These strips pass under a "cutter," which cuts them into 3-in. lengths. Here, again, there is no waste or scrap. When the trays carrying these biscuits emerge from the oven, they are lifted out and placed on racks for a few minutes to cool, and are then tipped into boxes ready for packing. A continuous biscuit forcer to work by hand, used for Queen's and Rout biscuits, is shown in **6**. Hand biscuit cutters [**7**] are made round, oval, or fancy shapes, plain or engraved, with name for the use of those who make up their own biscuits, where hand kneading and the rolling-pin take the place of processes already described. These cutters are made to cut, print, and eject, like a machine cutter; also fancy

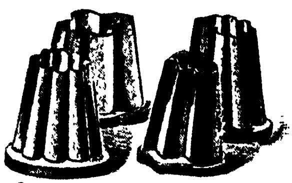
biscuit cutters [8], for rich and soft doughs, are made in strong tins of various sizes and designs.

Plain Ice Wafers. Probably the most important of special biscuits is the sugar or ice wafer. We illustrate here an automatic wafer-making machine [9], which is in use in all the largest factories in different parts of the world. This biscuit, so great a favourite with those who eat ices, is made of a mixture so thin as to be a batter instead of a dough. This batter is held in a tank at the side of the machine. A series of pumps distribute the batter in measured quantities upon silver-plated and highly engraved plates; these plates run in pairs, and as soon as the batter has been placed on the lower plate of the pair the top half closes and locks. The batter so held between the plates is carried round a chamber, which is heated by gas stoves. When the complete revolution of the machine has been effected, the plates unlock and the sheet of baked batter drops out. This sheet is made up of 32 of the finished wafers, and these are cut out from the sheet by means of rapidly revolving saws. All these operations are carried out automatically.



7. HAND BISCUIT CUTTER

Cornets. These are wafers shaped like cones, made on a machine somewhat similar to that used for plain wafers, but the plate consists of cone-shaped moulds, 24 in number, and the cover is fitted with a similar number of cone-shaped spikes which fit into the moulds. The moulds are filled with the batter by means of a special device which delivers into them exactly the right quantity of stuff, thus saving any waste. When the moulds have been filled the cover is clamped down, turned over, and passed on as before, the next plate coming round to be emptied. From it the cones or "cornets," which are either in the moulds or sticking to the spikes, are removed and packed in boxes. One plate takes five minutes to travel round the machine. About 9,000 a day per man are turned out. These wafers are largely sold to itinerant ice-cream vendors.

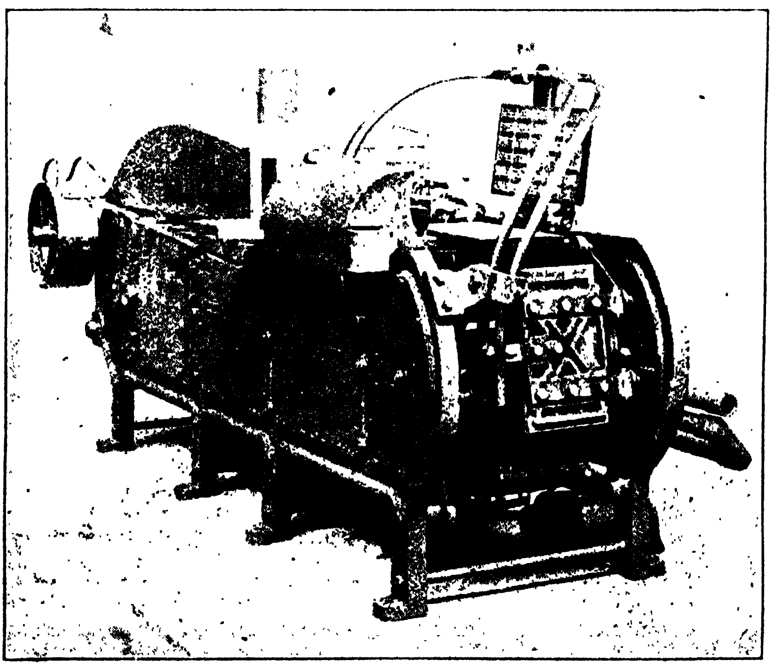


8. FANCY BISCUIT CUTTERS

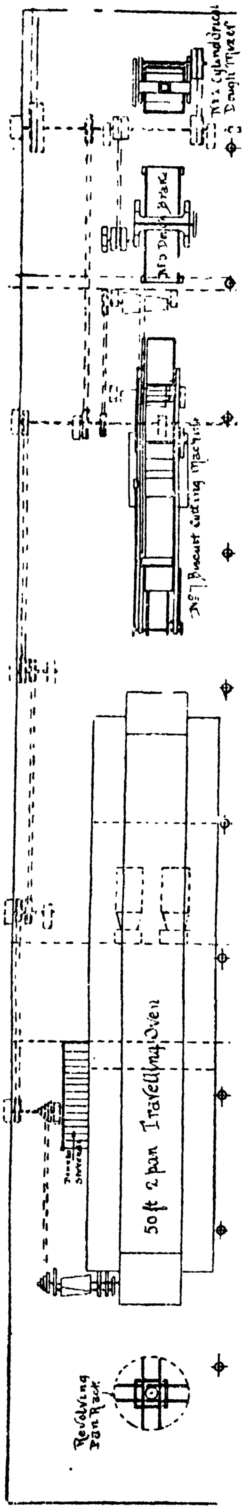
Windsor Wafer. The Windsor Wafer or Sugar Vanille consists of two plain ice wafers between which is sandwiched cream. The cream is put in between the sheets of wafers, which are then cut up and dried. If they were dried before being cut, bits of the wafer would chip off, and thus cause a loss.

Artificial Bananas. Among the various forms of confectionery now made is an imitation banana. This is flavoured with a concoction to give it the taste of a banana. It is shaped and coloured like a banana, and when broken is soft, like that fruit. Large quantities are shipped to Jamaica, Batavia, and Egypt.

Hand-made Biscuits. Cakes, even in large factories, are made by hand, though this method is rapidly dying out. There is also a certain class of biscuit, such as macaroons, which are sometimes made by hand, although generally on a drop machine. The shape of the biscuit is cut out of the dough by a hand cutter and then put on to an iron tray. When a sufficient number have been cut, the tray is put into an oven to bake, the tray simply lying on the floor of the oven. Its position is occasionally changed with the aid of a long wooden pole—technically called a *peel*—shaped at the end like a spade. When sufficiently baked the trays are taken out, and the biscuits are allowed to cool and are then tipped into boxes.



9. AUTOMATIC SUGAR OR ICE WAFER MAKING MACHINE (J. Baker & Sons, Ltd.)



10. THE ARRANGEMENT OF A SWEET BISCUIT FACTORY

Packing. Most biscuits and small cakes are packed in tins holding about 9 lb. of biscuits Each tin is put on to a travelling belt, which carries it to a hoist that conveys the tin to the floor above, where it is labelled. The tins are then put into a hot chamber to dry the labels to prevent them rusting the tins. Tins used for export are hermetically sealed. A certain class of goods, such as "Quaker Oat Biscuits," are packed in cardboard packets called "boxets." These boxets are waxed inside, and the biscuits are wrapped in waxed paper before being placed in the box. The life of a biscuit tin is about five or six journeys. The tins are well scoured out every time they return to the works.

Refrigerating Plant. This is an essential part of a large factory. It is used for cold storage of butter and lard, for ice making and milk cooling. [See FOOD PRESERVATION.]

The complexity of the work of a large biscuit factory may be judged from the fact that one large firm may turn out 250 varieties. We give, in **10**, the general arrangement of a small sweet biscuit factory.

Ship and Dog Biscuits. The method of manufacture of ship biscuits, as in the works of Messrs. Spillers & Baker, who have the latest installed plant, is conducted somewhat on the following lines.

A selection is made of specially milled flours of a description and quality suitable for the biscuit required, ship biscuits being usually made in several qualities, some for cabin and some for crew use. The mixture and blend having been decided upon, the various flours are put through a set of automatic mixers, which blend them thoroughly together. This mixed flour is then caught off from these mixers in sacks, each one being carefully weighed to ensure the exact quantity of flour being used for the next process. A charge of from 5 to 10 cwt. of the mixed flour is then shot into a dough mixer. Fixed above is a tank connected with a supply of pure water, and by means of a gauge the desired quantity of water for the weight of flour is added. The mixture is kneaded into dough in from 15 to 30 minutes, and discharged on to an iron table immediately below, near which is fixed a brake, through which the dough is rolled backwards and forwards until a sheet of the required thickness is produced. The other processes of preparation for the oven being similar to those described above.

A Special Oven. The oven, which differs in some respects from that used for sweet biscuits, consists of a number of iron plates, which, being connected together and worked on tumblers, are made to traverse the whole length of the oven. The most approved size for up-to-date ovens is about 8 ft. wide and 44 ft. long. The length of time the biscuits take to pass through the oven can be adjusted by means of a ratchet-wheel and pawl at the front end, and they take from 15 to 30 minutes, as more or fewer teeth are taken by each upward motion of the pawl. The heat in the oven is regulated by an elaborate arrangement of flues and dampers, and as the ovens for this kind of biscuit are usually what is termed "direct heat ovens," a smokeless fuel, such as coke, has to be used; the consequence is that the heat produced is very much more intense than that in ovens fired by other methods, and has the effect of rendering the biscuits so baked capable of withstanding changes of temperature and keeping a considerable time. But because of this direct heat, ovens so constructed require very much more careful manipulation and closer attention, as the heat is apt to vary more than in "indirect heat" ovens.

By properly regulating the heat, and also by previous calculation, the biscuits, on reaching the end, are thoroughly baked. They are conveyed by elevators to a drying floor in order to cool and to get rid of any superfluous moisture that may be contained in them. After being stored on this floor for sufficient time, they are packed in barrels or bags for delivery where required. This final drying operation is not required in the case of sweet biscuits.

The method employed for the manufacture of dog biscuits is on similar lines to that just described, with the exception, of course, that the materials used are different. Great care has to be exercised in the selection of suitable flours and meals, and also in the addition of the cooked meat considered necessary for the dog's dietary.

Biscuit Making concluded

HOW, WHEN, AND WHAT TO EAT

Digestion and Diets. Meat Food. Regularity. The Three Meals. Influence of Mind on Digestion. Meal-time should be Cheerful

Continued from page 3381

By Dr. A. T. SCHOFIELD

SOME time ago the United States War Department made experiments with a view to reducing the weight and bulk of the soldiers' rations without impairing their nutritive value. It was soon known, however, that the experiment had resulted in failure. A report on the subject has now been issued from which some interesting details may be gathered. A company of the 7th Infantry, it appears, was detailed to make the experiment. The company was furnished with condensed rations, consisting of coffee, soup, bread, and bacon. The coffee and soup were in small tablets, which, when placed in boiling water, were ready for consumption in two minutes. The bread was in small, flat cakes, the weight and hardness of a brick, which, when moistened, swelled out like a sponge. The bacon was compressed, and needed only to be warmed in a frying-pan. The soldiers started out with 10 days' rations, but the campaign was brought to an abrupt end after four days of 15-mile marches. The food not only failed to satisfy hunger or give strength, but seemed to irritate the stomach.

Suitability of food largely depends upon its digestibility, as well as upon its chemical composition. Thus, it would seem that, from one point of view, pork and milk contain about the right proportion of carbon and nitrogen, and yet the one is a most unsuitable article of diet, the other the best we have. As a rule, the nitrogen in vegetables is not so easily absorbed as in meat.

Force Derived from Various Foods. With regard to the proportion of body and mind work derived from various foods, an attempt has been made to give a table showing the percentage of force that food gives out as heat, as physical force, and as mental energy. This is as follows, but must be taken as merely approximate:

PERCENTAGE TABLE

Foods.	Heat Force.	Physical Force.	Mental Force.
Rice	82	5	½
Prunes	78½	4	4½
Wheat	66½	14½	1½
Oats	51	17	3
Beans	40	24	3½
Ham	32	35	4½
Yolk of egg	30	—	2
White of egg ..	—	13	3
Cheese	28	31	4¾
Potatoes	16	1½	1
Mutton	14	21	2
Beef	14	19	2
Milk	8	5	1
Chicken	2	21½	3
Herring	1	16	5

The rest is water

This table gives the relative cost of foods:

COST OF SUFFICIENT FOOD TO SUPPLY THE AVERAGE DAILY FORCE NEEDED

	s.	d.		s.	d.		s.	d.
Codfish	5	0	Butter	1	7	Beans	0	6
Mutton	3	6	Cheese	1	6	Rice	0	5
Lean beef	3	0	Fat pork	0	9	Bread	0	4
Milk	2	3	Potatoes	0	7	Oatmeal	0	3½

This, of course, gives no idea of relative suitability or digestibility, and no one could live exclusively on any one article named, excepting milk and bread. Let us take a more general survey of the principles and practice of dietetics.

Importance of Proper Food. There can be no doubt as to the importance of the subject when we learn that in this country alone over 2,000 lives a week are lost through bad and improper food. Indeed, this is too low an estimate when we remember that food includes drink, and hence alcohol. It is sufficient, however, for us here to know that the misuse of food (including drink) is by far the chief cause of disease, death and misery in the English race, and that "proper food" is the first and foremost of the five laws of health.

Food is necessary, as we all know, to repair the waste of the body, and in its widest sense includes not only solid and liquid, but the gas we inspire from the air, under the name of oxygen. While, however, we have ultimately no control over the *amount* of oxygen we inspire, nor any choice of gases, we can and do adulterate the air as much as lies in our power, to our own cost. But our powers for evil over what we breathe are small and insignificant when compared with the wide powers and complete control that we have over the food we eat. One would think that the human race, when it became civilised and educated, would long ago have settled the question of food and drink, and have discovered the best and most economical way of repairing the system. *What* to eat or drink, *when* to eat, *how* to eat, should long ago have been questions so settled by experience and authority.

Repair of Waste. We require a good deal of food—for, as we have shown, we perish at a faster rate when we are alive than when dead, wasting to the extent of about one twenty-fourth part daily. We thus lose over a ton a year, and the important question is, how best the loss is to be made good.

This rate, however, is not even throughout life, and for the first twenty-five years we have to consider not only how to replace the daily loss, but how to build up the body and what material to use.

As regards quantity of food, the best and simplest rule seems to be: From the ages of 1 to 25, as much food as is wished, provided it be wholesome and given at stated intervals; from 25 to 55, as much food as will keep the body at the same weight for these 30 years: from 55 to 75, a gradually decreasing amount of simpler food, so that weight is slowly lost, or at any rate, not gained. In the first third of life we seldom eat too much; in the last third we very often do so.

The difficulty in writing on dietetics is to avoid being too explicit, and yet to give directions that are of real value. We shall try not to be too exact as to details, but very definite as to principles.

Digestion and Indigestion. When the digestive system is "in order" its great characteristic, like that of all other body systems, is that it performs all its work unconsciously. So perfect is its mechanism that we do not know or feel we have either stomach or liver, although both may be hard at work, and the former in violent motion for hours together. But once indigestion begins, this delightful unconscious calm vanishes, and we are only too painfully aware of the internal troubles.

In nearly every case this is our own fault, and is brought on through gluttony for food or excess in drink. Gluttony is a great vice, but being personal and harming no one but ourselves, it escapes censure, save when leading to excess in alcohol. An old German proverb says, "As a man eateth, so is he." It is true that our food influences our character, but it is equally true that our character affects our eating, and that the wise, self-governed man is far less likely to suffer from dyspepsia than the self-indulgent one.

Moderation the Motto of Health. Personal habits leading in this direction to ill-health are easily formed, and should be carefully watched. Small habits of excess are easily acquired, and are then so difficult to break.

We do not wish to lay down many rules, but say emphatically that "moderation in all foods" is the motto of health. This habit formed in youth is a powerful safeguard against many ills, and prevents much physical unhappiness.

We will first look at the question, "*What we should eat*," on which many opinions are held.

The natural query is, "Shall we exclude any ordinary staple food such as meat from our dietary, and if so, what?"

Our answer for those whose digestion is in order and who desire to keep it so, is "No. Let all ordinary food be eaten in moderation." But there are many who exclude "butcher's meat" and eat "white" meat only, others who forswear all meat, but eat other animal food such as milk, eggs, butter, etc., and are miscalled "vegetarians." Others, again, rise above these and eat vegetables only. A superior class still exists on fruits, but the highest and smallest class of all consists of those eccentric beings who are kept alive by nuts and seeds only, including, very largely, apple pips. To such heights of faddism or depths of imbecility does dieting extend, and in every stage there are men and women ever ready to demonstrate, in their own persons, that every conceivable energy and grace is produced by their particular diet, and to hand you convincing manuals that prove this.

Dietaries should be Shunned by the Healthy. All dietaries should be shunned by the healthy; their adoption is a confession of weakness, and even the weak should use diet tables as little as possible.

When we remember how different are people's temperaments and idiosyncrasies, and that what agrees with one so often disagrees with another, we see the difficulty, if not the folly, of laying down general dietaries. Dr. King Chambers writes: "Some cross off their dietaries everything that has ever disagreed; better to add to it everything that has once agreed." This advice goes rather too far, but it is on the right side.

After infancy, therefore, when the full digestive powers are established, diets do generally more harm than good, save in special diseases. Even if some food is found to disagree it is better to eat less of it than to cut it off altogether. We must remember, too, that cooking can render the same food digestible or indigestible.

The question to ask respecting any article of diet is, "Do you like it?" and "Does it like you?" If both questions can be answered satisfactorily, there is no doubt on the matter; if the first only, try the food in moderation and well cooked before you decide to give it up.

No doubt, not only gout but many smaller ills come from a wrong diet, and if a person suffering from any of these is told by a responsible physician that they are caused by any article of food, he should heed him and not use it; but we are speaking of the healthy, and of the self-dieting of dyspeptics.

Eating too Much and too Little. But "What to eat" embraces also what amount to eat, and we would touch on this, for it is most important. We think that most people who can afford to do so eat too much.

The rule we have already laid down of living by the scales rather than by the appetite is a golden one. Let the weight be fixed and never exceeded or lessened by half a stone. This is not only the way to keep in order, but to prolong life and to avoid many diseases.

Dr. Mortimer Granville says that there is "More danger from excess of food than from infection; and there can be no doubt that excess of animal food is a great and crying evil in the English people and produces an amount of dyspepsia and other troubles wholly preventable by eating half the amount. In this country we consume about four times the amount of meat of any other country in Europe."

Eating too much does not strengthen the body, but exhausts it with the labour of digestion and the evils of the undigested residue. Among the aged this is a common error, mainly due to friends and relatives who are continually urging the old man, whom Nature has wisely deprived of his teeth, to eat more and to live better; whereas his health and happiness depend on eating less and living more plainly.

While we thus speak against over-eating in the healthy and wealthy, we see plenty of evils arising from starvation among the rich.

Many eat too little for various reasons, even when otherwise in health; and this soon leads to the nerves or some other part being out of order. A false idea of refinement, or some slight dyspepsia or over-fatigue, leads to semi-starvation, and very soon nervous signs follow, showing the nerves are no longer in health.

So far, we fear, we have spoken in a very vague way for those who, as we have said, love exact rules. We will try to be a little more exact in speaking of one or two articles of diet.

Meat and Vegetarian Diets. Of meat we eat far more than the French or Germans. No doubt we require rather more than they do; but the excess over what we really require is enormous, and not only represents great waste but needless disease.

There is no storehouse in the body for excess of meat food as there is for fats and starches; and the result is that if the excess passes a certain point the meat becomes poison, and uric acid is produced.

For light workers meat once a day is enough. Butcher's meat three times a day is an excess for anybody in this country. The recent researches of Professor Chittenden tend to show that a far greater limitation of meat diet may be beneficial.

The bulk of the diet should be what is called—but is not—vegetarian; that is, farinaceous and vegetable foods, milk, with eggs, etc. In growing youth and early manhood too much care cannot be taken that the food is digestible; and above all, artificial and pre-digested foods should be avoided; for hard digestive work in moderation strengthens the stomach, whereas little or no work certainly weakens it. Thus, "meat teas" which are hard to digest are not bad for young people.

Bread the Staff of Life. Bread is the staff of life, and no attention should be paid to dyspeptic faddists who claim to have discovered rather late in the day that it is the source of much disease. It contains the meat and vegetable principles as no other food really does, and can be eaten in such a variety of forms that none need tire of it. White bread well made is the most nutritious and generally useful; for the weak and for children wholemeal bread is splendid, while Hovis bread is of real value as compared with other breads, on account of the amount of fat it contains, making it nearly equal to bread and butter. Italian pastes, such as macaroni, are exceptionally nutritious, and indeed no dish can surpass in food value macaroni and cheese, which is, perhaps, for its bulk, the most nutritious dish that can be made; but it does not follow that it is particularly easy of digestion.

We have already pointed out that the old idea that force is gained principally from meat diet has proved to be erroneous, and it is now shown that muscular force is principally obtained from the carbohydrates — the starch and sugar foods. These two can be eaten in excess with much greater safety than meat, as we have shown. Sugar itself is a most valuable muscular food and must be mentioned here. As a rule, it is taken plentifully in all farinaceous food, for all starch is changed into sugar. The advantage of sugar is that it requires no change. It exists in large quantities in some vegetables such as beetroot, in some fruit such as grapes, and also in chocolate and other artificial foods. If half a pound a day is eaten, from 15 to 20 per cent. more work can be done. Hackenschmidt, the great wrestler, gets nearly all his force from sweets, chocolates, etc. Seventy-two lb. per head is used in Great Britain, 52 lb. in America, 25 lb. in France and 17 lb. in Germany. Sugar creates no uric acid, and does not in itself produce gout. Two lumps of sugar eaten daily, will increase the weight 14 lb. in one year.

When to Eat. The next point to consider is "*When to eat.*" As to this, we may certainly say, "*At fixed times.*" Food eaten at irregular times is much more apt to disagree than if taken at fixed hours. This is truest in early and late life, but holds good all through.

A baby may suffer from birth from capricious feeding, and without fixed hours soon becomes a burden to itself and to others; whereas if fed every two hours in the day, and every four hours at night *by the clock*, it would be in health and perfectly easy to manage. It is astonishing, too, how soon a child becomes accustomed to fixed habits, and what an untold blessing these are; and this refers not only to eating, but to all habits necessary for the health of the individual.

Regularity of Meals. Perhaps we may be allowed to point out here the great misery that has resulted to, and is still experienced by, thousands whose digestive systems in some part of their course are out of order, solely from a culpable neglect on the part of parents in forming a daily habit in their children, and thus rendering constant medicine wholly unnecessary.

The advantage of regular meals is that the digestive organs themselves learn to expect these meals, and get ready for them if they are taken at fixed hours.

The interval between meals should never be less than four hours, and is better if not over six. It is most important that a fresh meal should not be taken until the last is digested. The neglect of this rule is a common cause of dyspepsia. The burning question of the number of meals in the day is by no means easy to settle.

We have been recently invaded from America by a no-breakfast agitation, which, though not so much needed here as in the States, raises a very important question. In America breakfasts have run to such an excess as to become veritable banquets.

No breakfast at all may suit some, but the folly is to think of this or any similar device as a universal panacea.

Three Kinds of Breakfast. Three sorts of breakfast remain for those who take any; they may be summed up as the *English breakfast*, the *plain breakfast*, and the *French breakfast*, each admirably adapted for certain cases.

The man or woman who has to do hard physical work before lunch, and especially in the open air, does well to eat a hearty breakfast, allowing, say, an hour afterwards before beginning work.

The man or woman who has light physical or mental work to do, and whose forenoon is spent more within doors, does better with the plain breakfast, with perhaps an egg and some marmalade; or with the still lighter "French breakfast."

The general consensus of hygienic wisdom lays down that the principal meal when the man's work is over by one o'clock is the lunch or early dinner; while all-day workers do better with a light lunch and a more substantial dinner. Where there is hard labour all day, practically two substantial meals, or dinners, are needed. The principal meal, at any rate, should be eaten, if possible, when the chief work of the day is over, and, let us repeat, must always be eaten at leisure. Quantity is the point in early dinners, variety in late dinners; for the digestion at that hour cannot deal with such large quantities of food as earlier in the day, and variety stimulates the appetite. Light tea is best taken as now, between four and five.

The Evening Meal. One last point remains as to when to take food, and that is with regard to the interval between eight or nine p.m. and eight or nine next morning. Though this long fast may not be a common cause of dyspepsia, it is certainly a common cause of wakefulness and nerve troubles, and many a slight nerve case has been cured by providing a meal between these hours.

If the evening meal at eight be plentiful, and if the night be spent in sleep, nothing is, as a rule, required till breakfast next morning. But this turns on two "ifs," either of which may fail. Sometimes the dinner is at six or seven, and very little may be eaten; in this case some sort of supper at ten or eleven is needed. Again, the night may be wakeful, and the person sick from hunger, and yet no food can be had till breakfast-time.

This should never be. Food of some sort that is palatable when cold should always be accessible, so that an impromptu meal can be taken with some milk when required; while those who always have their evening meal early, and often eat little at it, should, as we have said, as a fixed custom have a light after-supper about four hours later, and if any part of it can be hot so much the better for digestion. There is really no necessity for walking a mile after this supper. If a brief interval be allowed before retiring to rest, the meal will not only give no trouble but will probably act also as a mild hypnotic.

How to Eat. The third and last point is "*How to eat.*" Now, all things may be lawful, but all are certainly not expedient, for while there may be no sin in eating all that is set before us, there is often suffering if we do.

Sir Henry Holland's three rules for eating were:

1. Never to fill the stomach to repletion.
2. To eat slowly.
3. To allow no mind strain at meals.

These may not sum up all that is needful to keep the digestion in order, but they are wise and good as far as they go.

The first rule may be put in another form, perhaps more refined: "Always rise with an appetite."

The reason of this is that when we have really eaten enough the hunger is often not wholly appeased *at the time*, because the food has not yet had time to digest. Therefore, even if we rise "with an appetite," it soon disappears as the food becomes assimilated.

Over-eating of animal food is more serious than that of other kinds, for in this case, sooner or later, gout is almost sure to supervene.

The next rule is to *eat slowly*. This all may do; and if they cannot, they should eat only the lightest food when in a hurry.

The third point is most important—"*no mind strain at meals.*" The same simple meal that will perfectly agree with a man in ordinary circumstances may cause violent dyspepsia if eaten under severe mind strain or shock. Even if done once, the bad effects are felt; and, if continued, chronic dyspepsia is the sure result.

Influence of Mind on Digestion. We must impress this point—that to keep the digestion in order heavy meals must never be eaten when the mind is agitated or strained. At such times the simple and wise course is to live on light food until the mind is relieved. The neglect of this simple precaution often begins the fatal reaction that culminates in a nerve attack. The attack of dyspepsia reacts on the mind, which becomes more nervous and strained; this weakens the stomach still more, and the process goes on till the system is impoverished and nervous debility ensues; and then, indeed, when the fatal circle is established, it is seen too late how much better and easier prevention is than cure.

The connection of stomach and brain, of digestion and thought, is very close. Good blood supply and nervous energy are as necessary for one as for the other, and the two cannot be fully working at the same time. It is, therefore, always advisable that a meal time should be a season of relaxation and of cheerfulness.

If this advice is needed for those in health, it is still more important for dyspeptics. A man who is liable to indigestion, and who eats a full meal when in a state of mental tension, may bring on a sharp attack of gout by so doing.

Continued

AN AGE OF DISCOVERY

The Wars of the Roses. Warwick "the King-maker." Murder of the Little Princes. Introduction of the Art of Printing. Discovery of a New Continent

Continued from page 3465

By JUSTIN McCARTHY

ONE of the most important events in the course of English history was the outbreak of the Wars of the Roses. These wars were carried on in maintenance of the rival claims of the houses of York and Lancaster to the English throne. The Lancaster family were descended from John of Gaunt, Duke of Lancaster, fourth son of Edward III., while the York party were the descendants of Roger Mortimer, grandson of Edward's third son. The Lancastrians adopted the red, and the Yorkists the white rose, as their emblem, and thus this prolonged contest, which lasted some thirty years, came to be described in history as the Wars of the Roses.

The Wars of the Roses. We read that in these wars perished 12 princes of the blood royal, more than 200 nobles, and more than 100,000 of the aristocracy and their dependents. It is not necessary to follow minutely the story of these wars and to recount the victories now of the one side and now of the other. Nothing could well have been more barren, so far as the prosperity of the country was concerned, than those trials on successive battlefields of family claims which seem to readers of the present day to rest on merely technical questions as to the law of succession. Even where it was shown that the immediate and direct line of succession had been broken, it was argued on the other side that on the death of a sovereign, the existing constituted authorities charged with the welfare of the realm had always claimed, and on several occasions exerted, without opposition, the right to designate for the throne one of the royal princes not actually next in the line of succession.

The record of these wars is sickening and ghastly to a degree which the stories even of civil wars cannot often equal. The rival parties do not seem to have behaved towards each other with any regard for the common laws of war as prevailing between rival countries. The Yorkites and the Lancastrians acted on the principle that in such a struggle each party, when it had won a victory, was honourably free to act towards the conquered leaders as if they had been mere mutineers, for whose breach of discipline any punishment might properly be inflicted.

The King-maker. The wars began in 1455, but the actual dispute had been going on since 1449, when Richard Duke of York publicly claimed the succession. One leading figure in those wars was that of Richard Neville, Earl of Warwick, the famous "King-maker." When the war broke out, Warwick rendered great service to the Yorkites at the battle of St. Albans, and was, indeed, the main instrument in obtaining the victory. After this he took the leading part in the struggle. He had more in him of the statesman than of the soldier, and it does not appear that mere love for soldiering had brought him to the battlefield. He was shrewd, astute, foreseeing, had a gift of political intrigue and political mastery, and was unscrupulous as to the means by which he accomplished his end. There were victories and defeats on either side, but Warwick effected a bold stroke by marching on to London with Edward, son of the Duke of York, and proclaiming him King Edward IV. Soon after the Yorkites gained a signal victory at Towton, and for the time the struggle seemed to be at an end.

The young King made himself very popular by his courage and his winning manners. Indeed, at that time, London was well inclined to welcome any sovereign whose coming to the throne brought with it the promise of restored peace.

Edward later on made many enemies by his licentious tendencies, and Warwick, among others, turned against him. Edward found that there were strong forces opposing him, and he left England and took refuge in Flanders while he was gathering new strength around him to meet his enemies. After six months he came back to England, and with his brother Clarence, who had recently taken his side, encountered his opponents at Barnet, April 14th, 1471, where Warwick the "King-maker" was surrounded and killed on the battlefield.

Tewkesbury. The result of the battle was a victory for Edward, and by a subsequent victory at Tewkesbury a few weeks later he brought that chapter, at least, of the war to an end. Edward behaved with extreme cruelty to some of his captured enemies, and the latter part of his career illustrated in very striking fashion the general character of those lamentable Wars of the Roses. On April 9th, 1483, he died suddenly. When his life ought to have been only at its prime it was prematurely brought to an end by the excitement of politics and war, and probably even more by dissipation. His successes were made for him by others, his faults and failures were his own.

He was succeeded—at least nominally succeeded—by his son Edward V., who was then little more than twelve years old. He came at once under the influence of his uncle, Richard, Duke of Gloucester, the youngest brother of Edward IV. Richard, Duke of Gloucester, is one of the most remarkable, and one of the most odious figures in English history. He is, perhaps, best known not through history, but through the drama. Shakespeare in his "Richard III." has made for us a terrible picture which is as living as life itself, and even if every fact and incident in that great drama is not a literal reproduction of the truth, his

character of Richard may be taken to be a fair representation of the real man.

Richard was born on October 2nd, 1452; on the defeat and death of his father, the Duke of York, he was sent abroad for safety, but after Edward IV. had won the throne he returned to England and was made Duke of Gloucester. He took a conspicuous part in the York and Lancaster struggle during its later developments, and is accused of having sanctioned, or even promoted, some of the worst crimes—the judicial murders of leading opponents during that war.

The Murder of the Little Princes. After the death of King Edward, Richard was appointed Protector of the Realm and guardian of Edward V., then only thirteen years old. He became practically ruler of England for the time, and the Queen-dowager was induced to put under his guardianship also her younger son, the Duke of York. The two boys were put into the Tower of London with the avowed object of keeping them safe. They were afterwards murdered there, it was generally believed, by the orders of Richard. Richard the Protector had Earl Rivers and Lord Richard Grey, the uncle and the stepbrother of young Edward, arrested on a charge of treason and brought to a trial which ended in their execution. Richard now seemed to be absolute master of the state, and he was invited by the Parliament to accept the crown. This invitation, entirely in accordance with Richard's own ambition and schemes, was promptly accepted by him, and he was crowned king.

Bosworth. In the meantime the feeling of hostility to Richard and his deeds was spreading throughout the country, and some of the most powerful nobles began to turn against him. Henry Tudor, Earl of Richmond, was then the most important representative of the House of Lancaster, and the friends of this powerful nobleman began to organise a scheme to dethrone Richard and make Henry Tudor king. The attempted movement failed, and its principal leader, one of Richard's earlier supporters, the Duke of Buckingham, was put to death for the part he had taken in the projected rising. Henry, Earl of Richmond, had no ideas of abandoning his hostility to King Richard because of any temporary check to the movement in his own favour, and on August 22nd, 1485, he encountered Richard at the famous battle of Bosworth, in Leicestershire. The battle was a complete defeat for Richard, who was deserted at the last moment by some of those who had, up to that time, supported him. Richard lost his life on the battlefield.

There was a story widely credited for a long time that Richmond was actually crowned on the battlefield as King of England with Richard's own crown, which was found when the fight was over not far from the spot where Richard had fallen, but the story is probably only another illustration of the romance of history.

Richard III. was a man of distinct and remarkable capacity who might, under other conditions, have made a great name for himself and have been a benefactor to his country. Intellectually and in education, an education in great part self-acquired, he was in advance of most of the English princes of his time; but his ambition, impatience, and his recklessness of all moral restraint, illumined only with a lurid light that chapter of history which encloses his reign.

With the death of Richard III. the Wars of the Roses ended. Henry Richmond became without further struggle the successor to the English throne. His father, Edmond Tudor, belonged to a celebrated Welsh family, was the son of Owen Tudor, who bore a name distinguished in the history of Wales, and of his wife, Queen Catherine, the widow of Henry V. Henry VII., soon after he had come to the throne, married Elizabeth of York, eldest daughter of Edward IV., and by this marriage the red and white roses became united.

Introduction of Printing. A new chapter of wider significance and more enduring influence in the history of the world than any associated with the rivalries of states or the fortunes of contending armies, was opening about this time. This was the chapter which tells of the discovery of the art of printing. Up to this period authorship of whatever kind had to address its public through the form of manuscript. Books had been made up of letters written with the hand on pages of parchment, paper, or even of leather, but the only medium of communication between the poet, the historian, the romancist, and the outer public was the character traced by the human hand. It is said that a sort of block printing, the impressing of words on paper or parchment through the medium of wooden carvings representing the words, was discovered in China some five centuries after our Christian era, and practised there for some time. There is evidence of similar inventions and applications having been made the subject of experiment at later periods in European countries, and of having been practised there with some success.

The idea might have come into almost any mind, at any period since works of literature came to be composed, that there might be some mechanical process for reproducing on parchment or paper the text of the author in a form at once more legible and more capable of rapid multiplication than could be accomplished under any conditions by hand. But the art of printing, as it is understood in modern days, seems to have come into use in different parts of Europe at about the same period in the world's development—during the fifteenth century. The name of William Caxton will always be identified in England with the earliest practical application of the art of book printing.

Caxton. Caxton was born in the Weald of Kent, about 1422, and was in his boyhood apprenticed to a London mercer, afterwards Lord Mayor of London, who seems to have been a kindly protector to the young Caxton. When the mercer died, in 1441, Caxton went over to Bruges, became one of a company of English traders who had settled there, and in the course

of time rose to be a governor of the company or association. It was while in Bruges that his attention was attracted to some experiments going on there and in other parts of the Low Countries, as well as in Germany, for the construction of a system of mechanical printing—the reproduction of words and sentences by means of a stamping process which should make the reproduction capable of infinite repetition. It may be that the attention of Caxton was originally drawn to the importance of some such process of rapid and multiple production not merely by the interest he always took in the reading of books but also by the fact that during a great part of the time which he spent in the Low Countries he was engaged as copyist to a family of high rank. His attention was soon caught by the efforts going on for the introduction of some method of providing reading matter for the public otherwise than through the toil of the human hand.

The First Printed Book. Caxton made up his mind that his best business in life was to become a producer of books, not merely in the capacity of an author but in the capacity of one who supplies the public with books almost any number of which can be produced within a limited space of time, and can be read without straining the eyes of the student. In the preface to his first printed work he tells of the trouble it cost him to copy with the pen: "My hand weary and not steadfast, mine eyes dimmed with overmuch looking on the white paper. Therefore I have practised and learned at my great charge and dispense to ordain this said book in print after the manner and form as ye may see, and is not written with pen and ink as other books be, to the end that every man may have them at once, for all the books of this story here emprynted as ye see were begun in one day and also finished in one day."

This first book printed in the English language was printed in Bruges under Caxton's instructions; but after he had made England his home, and had taken service as a kind of household manager and secretary with Margaret, Duchess of Burgundy, sister of Edward IV., he brought out the first English book actually printed in England—"Dictes and Sayings of the Philosophers," published in 1477. Caxton now set up a printing press at the sign of the Red Pale, in the Almonry at Westminster, and although he was now growing old—he died about 1491—he threw himself into his new work with an energy which would have done credit to youth.

Development of Printing. The public seems to have been taken at once with the opportunity thus offered of having an almost unlimited number of copies of some popular work put into circulation at the same time. England cannot claim to have been the first to bring out printed books, but she may claim to have been the first to make the printing of books a regular institution, and to have found for them a steadily increasing public.

Caxton was a lover of literature, and he gave to the world printed versions of all the English poetry then to be had, foremost amongst which was his edition of Chaucer's "Canterbury Tales." He collected and printed the poems of Gower, he gave to his readers a version of the Æneid, taken from a French translation, and some of the writings of Cicero. Caxton's own tastes led him to a pure and simple English style, free from the pedantic affectations delighted in at that time by writers who had not yet recognised the fact that a new epoch was arising for the English language as well as for the English people. He made translations of his own, and he helped to put together many books which had to do with the trade and commerce of the time. Many of the productions of his printing press are still preserved, either in complete copies or in treasured fragments, kept as heirlooms in families or carefully guarded in public institutions. The printing art spread rapidly over a great part of Europe. There were printers busily occupied during the days of Caxton at Rome, Venice, and Milan, while France, Germany, and the Low Countries became occupied at a very early period in the great new movement. A new world of letters was beginning to grow up, and the clearest practical evidences were given that humanity was no longer content to live intellectually on the bequests consigned to it by the ancients. Science was also beginning to makes its existence known—science, that is to say, as we understand it now, the study of actual realities, and the discovery of systems founded on careful calculation and comparison of figures and facts, and not the mere theories and exalted speculations of gifted philosophical imaginations.

Invention of Gunpowder. Not very long before the discovery of the art of printing—indeed, almost about the same time—another art had been discovered which had a very different effect on the whole subsequent history of mankind from that wrought by the use of printing—the art of making gunpowder. The invention of gunpowder is generally believed to have been the birth of one of the closing years of the fourteenth century. There are, indeed, some theories that it was in use long before that time in China and in Hindostan, and it is certain that Roger Bacon, who died in 1292 or 1294, mentions in one of his treatises the existence and the use of such a composition. But the uses of gunpowder as the great weapon of war had only come into recognised and universal application a short time before the printing press had created a new era for literature, for science, and for popular education.

The earliest effect of this new ingredient in the making of war was to render the sovereigns and nobles more powerful than they had ever been, and to give, for the time, a lessening chance to any popular efforts towards the resistance of tyrannical and oppressive laws and forces. When the weapons to be used in war were only made of iron and steel, the peasant insurgent could use his edged and pointed weapon, however rude its construction, with much the same effect as the knight could use his burnished sword blade or polished lance-head. But the making of gunpowder required science and skill,

large capital, and the employment of scientific artificers, and was not to be accomplished by sufferers from oppression who belonged to the humbler classes. There came a time, indeed, when gunpowder was made to serve the cause of popular revolution as it had served the cause of dynastic and feudalistic oppression, when it became the servant of plebeian uprising as readily as that of patrician down-trampling.

Christopher Columbus. The discovery of that vast region which we still call the New World belongs to this period. Christopher Columbus was born in Genoa, in 1447, and was brought up by his parents to the business of a woolcomber. He soon developed a passion for the life of the sea, and at fourteen years of age he became a sailor. The vessel on which he was engaged had many fights with roving galleys belonging to Tunis, and the young man underwent several perilous adventures. As the result of one of these, he had to escape on a plank from shipwreck, and was flung ashore on the coast of Portugal. He settled in Portugal for a time, and there became possessed with the belief that a new way, and the best way, for reaching India would be by sailing westward. He formed elaborate plans for an expedition with that purpose. He submitted his project to King John II. of Portugal, later to Henry VII. of England, and still later to Isabella, Queen of Castille. His plans were at first rejected, but Columbus was persevering, and pressed them again and again, and after seven years of alternating hope and despondency he succeeded in securing the patronage and support of Ferdinand and Isabella—then rulers of Spain. His plans were accepted in April, 1492, and on August 3rd in the same year Columbus, now an admiral, set out on his voyage of discovery in command of a small vessel, the Santa Maria, with a crew of fifty, accompanied by two smaller boats. In his first voyage he came upon the Bahamas, and afterwards reached Cuba and Hayti. In his second voyage he came upon Dominica in the West Indies. These voyages were disturbed by many wrecks, and he found it hard to keep up in his crew the nerve and the patience needed for such adventures.

Discovery of America. After many quarrels with his associates and a long illness he returned to Spain in deep depression, but not yet content to abandon all his hopes. He organised a third expedition, the result of which was the discovery of the South American continent. His last great enterprise was a voyage in which he found his way to the south side—the Gulf of Mexico. Columbus had discovered North and South America, won for himself an undying fame, and opened out an entirely new world for all explorers and settlers. The fame he acquired was not the fame which he had sought, and it might almost be said that he became, in spite of himself, the greatest discoverer of new realms that humanity had ever known.

We shall have to trace the growth of North and South America, and especially the manner in which the northern continent came to be one of the most important and powerful among the states of the world, the shelter and the home of people from all regions of the earth, and how it gave to the republican principle of government its most enduring illustration since the birth of Christianity. Columbus settled in Spain after his great discoveries, where his most powerful, enlightened, and generous supporter was Queen Isabella. But the greatness and importance of his discoveries made enemies for him there, because ambitious nobles and others believed that Columbus was bent upon a career of self-aggrandisement at the expense of all opponents.

Columbus died on May 20th, 1506, at Valladolid, little more than a year and a half after the death of his patroness and friend Queen Isabella, and at the time of his death he was suffering severely from the injustice and persecution employed against him by the Spanish Government. It is a characteristic illustration of how Columbus failed to have early justice done to his career that the two great continents which he discovered should not have recognised him in their established name. We have North America and South America—the name of each continent taken from that of Amerigo Vespucci—a Florentine who was a provision contractor at Cadiz. During the early part of Columbus's career Amerigo Vespucci had contracted to supply him with provisions for some of his expeditions, and later on he made a voyage to the New World on the track of Columbus, on the strength of which he afterwards claimed to have been the first to discover the continent.

The First English Settlement in America. That New World remained for a long time mainly an exploring ground for Spanish colonisation, and the names of Cortes and Pizaro will always be associated with certain parts of it. There were many French conquests and colonisations there—and, indeed, most of the states of Europe sought for settlement on its territory. The first English settlement in America was accomplished by Sir Walter Raleigh, at Rowanoak, Virginia, which was called after the Virgin Queen Elizabeth. The discovery of the New World, and the opening it gave to the enterprise of Europe come appropriately in this chapter because they bear testimony to the spirit of practical and scientific discovery and inquiry which forms so impressive a characteristic of the whole period. The struggles going on about the same time between rival states in Europe did not prevent European sovereigns from encouraging adventurers and explorers of every kind to seek out territory in the newly-discovered world, and to annex new dominions to the seignorial possessions of European crowns. The two great American continents give evidences of the rush which was made upon them by foreign invaders, but while North America came more and more into affinity with England, the continent of South America was from first to last the colony of various states on the continent of Europe.

Continued

TRACK EQUIPMENT

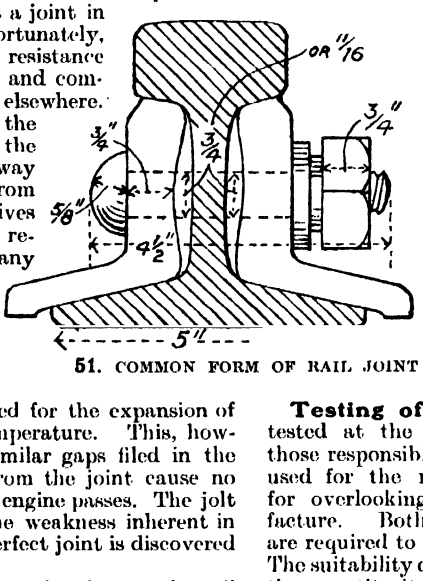
Railway Joints, Crossings, and Points. Friction on the Rails. Water Supply. Culverts, Fencing, and Platform Structures

RAILWAY CONSTRUCTION continued from page 3437

By R. W. WESTERN

Rail Joints. The simple expression *rail joints* comprises what has always been, and still is, one of the main difficulties of making a satisfactory railway. The forms of joint are innumerable; none is perfect. A common form is shown in section in **51**.

To understand the requisites for a good rail joint it is necessary to have a clear idea of the mechanical action of the loaded wheel passing along the rail. The rail is bent concave upwards between the sleepers between which the wheel is at the moment, and concave downwards both in front and behind, but particularly in front. The action will be better understood in detail by the light of the theorem of three moments. Thus, as an engine moves over the line it is accompanied by a wave in the rails which subjects the upper and lower flanges alternately to tension and compression. When this wave reaches a joint in the rails, it reaches, unfortunately, a place at which the resistance offered both to tension and compression is less than elsewhere. Consequently the rail, the immediate support of the wheel and flange, gives way unduly at this spot, and from the very fact that it gives way, this spot, of course, receives heavier jolts than any other part. There is a popular belief that the shock which is often distinguished in a railway carriage as the wheels pass over a joint, is due to the gap provided for the expansion of the rail on a rise in temperature. This, however, is not the case. Similar gaps filed in the head of the rail away from the joint cause no appreciable shock as the engine passes. The jolt at the joint is due to the weakness inherent in the joint, and until the perfect joint is discovered the jolt is inevitable.



51. COMMON FORM OF RAIL JOINT

The *stiffness* and *moment of resistance* of a rail at the joint should be the same as elsewhere. This condition has been the aim of all designers of rail joints, and it must be the object of all whose business it is to see that rail joints are made and maintained that these conditions are as nearly perfect as circumstances permit.

Provision for Joints. The joint is supported by placing the sleepers on each side of it closer together than the others. In light railways the joint may be placed on the top of a sleeper. This method cannot be used on heavier lines, as the weakness of the joint causes pressure at this point to be less distributed than elsewhere, and the sleeper over which the joint is placed is soon knocked out of level.

The plan of making the rails *break joint*—that is to say, placing the joint of one rail half-way between joints of the other—is sometimes practised.

Care must be taken that the proper odd lengths of rail are used in curves, as otherwise the sleepers will come to be unevenly distributed, producing an ununiform road-bed. Thus, if there be a sleeper at each joint and five between, the effect of the joints in the inner rail being displaced forwards on rounding a curve is to bring the sleepers under the first part of the next rail nearer together, and this defect continues after the curve is passed and until corrected. The advantage of making the rails to break joint is the increased resistance which is thereby given to any lateral displacement of the line.

In general, the joint sleepers in the case of a suspended joint should be a distance apart equal to six-tenths of the distance apart of the intermediate sleepers. A *suspended* joint is a joint placed between two sleepers, which are called *joint sleepers*. The advantage of longitudinal sleepers in facilitating the design of a good rail joint will now be understood.

Testing of Rails. Rails are generally tested at the works where they are rolled, those responsible for the quality of the material used for the railway stipulating for facilities for overlooking the whole process of manufacture. Both chemical and mechanical tests are required to establish the value of a steel rail. The suitability of the metal chiefly depends upon the quantity it contains of various metaloids—carbon, phosphorus, silicon, and sulphur. The effect of these substances upon the properties of steel may be studied in another section. For the present purpose it is sufficient to say that sulphur should be absent, phosphorus should not exceed 1 per cent., silicon should not exceed ·2 per cent., carbon should exist in quantities between ·33 and ·45 per cent., a rather larger proportion being allowed for heavy rails, but not more than ·55 per cent. in any case.

A high proportion of carbon renders the rail very much harder, and therefore more resistant

to wear, but at the same time it renders it brittle, so that a high proportion of carbon is suitable only for strong, well-built roads, over which a great deal of heavy traffic passes without much shock. From this it will be seen that a high carbon steel is not suitable for new construction at all, since, however carefully built, a recent construction is always liable to irregular settlement, and new roads seldom have very much traffic to deal with at first. The presence of nickel adds to the durability of a rail, and nickel steel rails have been used for this reason on curves over which a heavy traffic passes, but the advantage here conferred has to be carefully balanced against the extra cost of introducing the nickel. The inspector for the railway is usually furnished by the manufacturer with an analysis of the steel made each day from drillings taken from a test ingot.

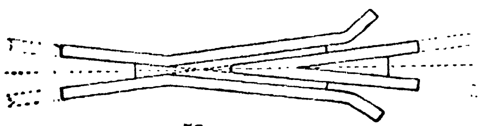
Mechanical Tests. The mechanical tests include the ordinary determinations of elastic limit, ultimate strength and elongation at rupture, but in default of these or in addition to them it is very common to resort to the drop test. Where rails are not specially rolled for the construction of the road, the drop test furnishes a ready means of ascertaining the quality of the metal of which they are composed.

The Drop Test. For the drop test the rail is placed on solid supports 3 ft. apart, and a ton weight is allowed to drop upon the rail midway between the supports. The total length of the rail should not exceed 6 ft., or the weight of the overhanging portions will add to the resistance of the central part. For rails of 50 lb. weight to the yard the drop should be 14 ft., and 1 ft. may be added for each increase of 5 lb. in the weight of the rail per yard.

The rails should correspond accurately to the prescribed weight. Variations in section should not exceed $\frac{1}{32}$ in.; variation in length should not exceed $\frac{1}{4}$ in. The holes for the bolts at the joints must be accurately placed, and must be clean—that is, free from burrs.

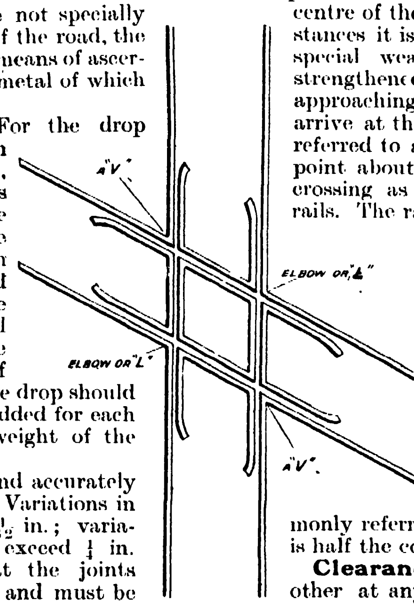
Rails must show no irregularity on top, but be perfectly smooth; the ends must be cut precisely at right angles and all burr removed. It is convenient if the name of the manufacturer be rolled in raised letters on the side of the web of the rail, together with the date, and it is sometimes provided that the number of the "blow" shall be stamped there, so that if a number of rails from one blow prove defective, the remainder may be identified. The *heat treatment* of steel should be studied in the article on metallurgy, as the future useful service of the rail greatly depends upon it. Rails being *the* essential things about a railway, it is impossible to know too much about them.

Points and Crossings. The advantage of constructing the tyres of the wheels of rolling-stock with flanges in order to guide them along the rails is accompanied by the drawback that, whenever it is desired to transfer rolling-stock from one set of rails to another, the continuity of the latter must be broken. Gaps set in the rails to permit the passage of wheel flanges are called *crossings*.



52. A FROG

The Frog. A diagram is given [52] of the gaps provided at the place where two lines of way first come into contact; it is often referred to as a *frog*. The point in the middle where the dotted lines are seen to cross each other is the centre of the crossing. It will be seen that the two rails approaching each other from the left meet in a point which is not extended to the centre of the crossing, but rounded off before this is reached. There is danger lest the flanges of wheels passing from right to left should strike this point if it be advanced too close to the centre of the crossing. Under any circumstances it is a place that is subjected to special wear, and must be fixed and strengthened with special care. The rails approaching each other from the right arrive at their minimum distance apart—referred to as the *throat* of the frog—at a point about as far from the centre of the crossing as the termination of the other rails. The rails then increase their distance apart, and pass on each side of the opposing rails, forming a guide for the outer side of the flanges of the wheels of the rolling stock, and are finally splayed out to avoid any danger of being struck by the flanges of wheels coming from the other direction.



53. LARGE ANGLE CROSSING

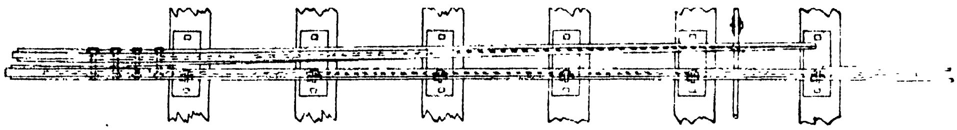
The Angle. The inclination of the two sets of rails to each other is the *angle of the crossing;* it is commonly referred to by number; the number is half the cotangent of half the angle.

Clearance. Lines may cross each other at any angle. In order to understand the provisions which should be made to enable this to be done with safety, it must be remembered that the flanges are upon the inner sides of the wheels and project about an inch beneath the level of the top of the rails, also that the distance between the side of the flange in contact with one rail and the side of the flange in contact with the other rail is rather less than the gauge of the railway—that is to say, there is always some play or *clearance* between the rails and the wheel flanges. When two lines of way cross at a large angle, as is

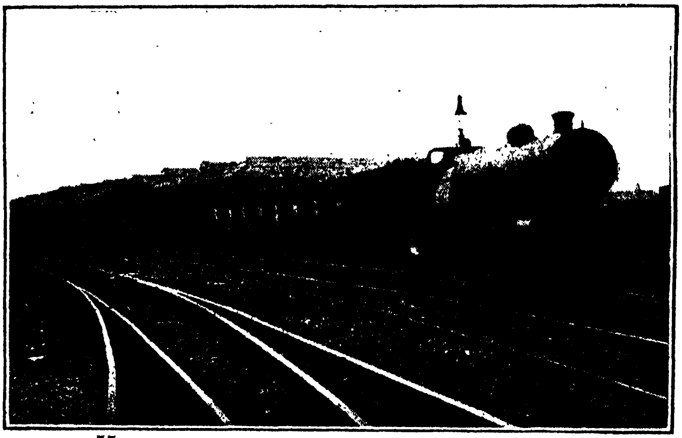
shown diagrammatically in **53**, a jolt as the wheel passes over the gap cannot be avoided. When, however, as in **52**, the crossing is made at a small angle, the jolt is very greatly diminished, if not entirely obviated. The effect of the acuteness of the angle of crossing is to bring the gaps in the rails into the form of an elongated parallelogram; and since the breadth of the tyres of the wheels is always made greater than that of the top of the rails, the wheel will have already reached the new rail before it has entirely left the old.

Guide Rails. It will be seen in **53** that additional rails are provided inside the usual rails to guide the wheels by confining the movements of the flanges on their outer sides. This has already been referred to in **52**. The effect of these is to provide that at the moment when one wheel is passing a gap, and therefore not so completely under the guidance of its flange as at other times, the other wheel fixed to the same axle is provided with a rail on each side of its flange, so that any tendency to movement fr m side to side is sufficiently opposed.

Switches and Points. One means of diverting a train from the track upon which it is running to another line of way has been sufficiently described in the account which has been given of the contractor's or temporary railway. These contractor's crossing and *stub* switches have been constructed with elaboration for permanent use, but have not been found satisfactory. On the permanent way the diversion of rolling stock is now universally accomplished, in the first instance, by means of a switch and completed by an *elbow* or "L," a gap in the rail, of which an example will be seen in the centre of **34**. The *points* or *switches* are names given to pointed rails that can be switched aside so as to be passed by the wheel flanges either on one side or the other, according to the position of the points. An illustration of a point, together with the *stock* rail or ordinary rail with which it is associated, is given in **54**. The points are well illustrated in the photograph [**55**]. The length of the switch, often called *tongue* rail, is usually about 15 ft. At the thick end it is pivoted, and here its cross-section is the same as that of the stock rail; its distance from the stock rail at this end must be sufficient to allow the flanges of the wheels of the rolling stock to pass between. At the other end it is pointed, and the movement of the pivot is to enable this end to be moved, either away from the stock rail so that the flanges of the wheels can pass at this end also, or close against it, so that the point comes between the wheel flange and the stock rail, thus diverting the wheel and causing it to roll upon the switch.



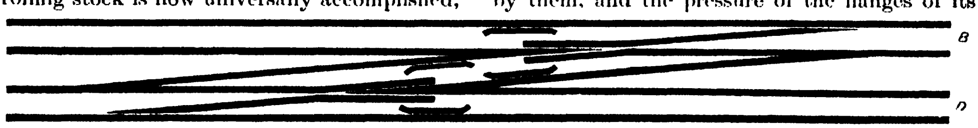
54. RAILWAY POINT



55. SECTION OF RAILWAY LINE SHOWING POINTS

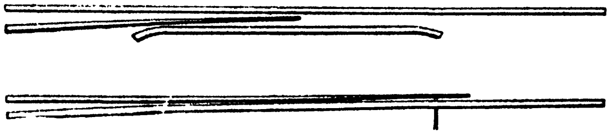
Cross-over Road. Fig. **56** shows diagrammatically the very ordinary arrangement provided for crossing from one to another of two parallel roads. The position of the frogs and switches and the guide rails will at once be recognised. The photo [**55**] also contains several illustrations.

Trailing Points. It will be seen [**56**] that trains passing from A to B come upon the point rails at the *heel* or pivot end first. Thus, whatever the position of the points, the direction of the train could not be affected by them, and the pressure of the flanges of its wheels would tend to press the point rails into their right position and retain them there.

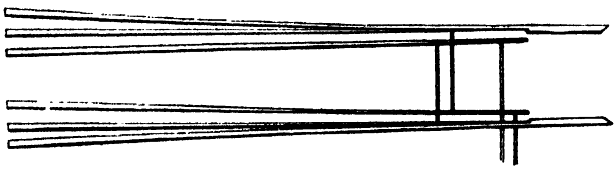


56. ORDINARY CROSS-OVER ARRANGEMENT OF RAILS

Facing Points. On the other hand, trains passing from B to A would come upon the

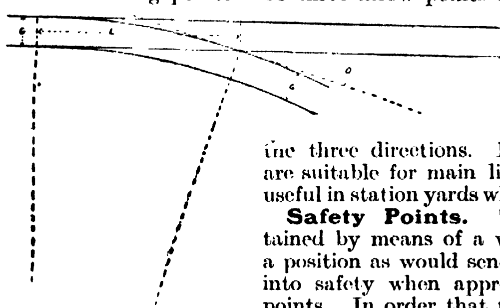


57. THE MOST SIMPLE SYSTEM OF POINTS



58. THREE-THROW POINTS

point rails, point first. Thus, if these were not in the right position the train would go wrong, and if, while the train were passing, the points where changed in position, the train would be broken in two, by the latter part of it being differently directed to the first. Facing points are, therefore, very much more dangerous than trailing points, and should be avoided wherever possible. Thus, if 56 be taken to represent a double line of way, the direction of traffic would be from A to B and from D to C, and not the other way about under any avoidable circumstances.



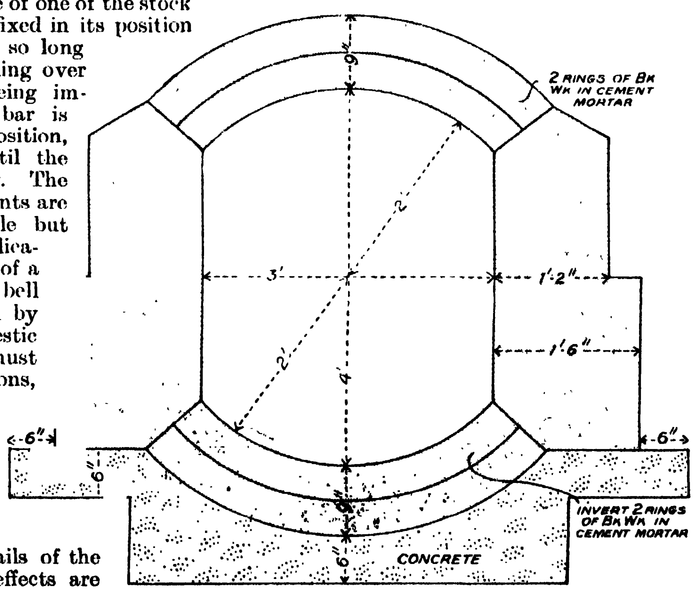
59. TURN-OUT FROM MAIN LINE

Locking-bar. In places where facing points cannot be avoided, the mechanism by which the points are shifted is best connected with a bar called a locking-bar, disposed on the inner side of one of the stock rails so as to be locked or fixed in its position by the flanges of the wheels so long as a train is passing or standing over the points. The points, being immovable while the locking-bar is fixed, are kept in one position, whether right or wrong, until the whole train has moved by. The mechanism by which the points are moved is simple in principle but exceedingly complex in application. It consists essentially of a series of links and elbows or bell cranks, such as are arranged by the bell-hanger about the domestic house. Since movements must be provided in both directions, rods must generally be used instead of wires, and the levers are usually connected with the signalling apparatus in such a way that the position of the points is known by the position of the signals.

Interlocking. The details of the mechanism by which these effects are produced and controlled from the signal-box are various and complicated, especially at crowded junctions, where there are often many acres of ground covered with crossing and branching lines of way. In these situations electric methods are now being introduced.

Varieties of Points. Points are not necessarily provided with more than one tongue. Thus, in 57 is shown diagrammatically what are still called points, though only one is, in fact, a movable point. It will be seen that the movement of this switch at the bottom of this figure will suffice to change the direction of a pair of wheels coming from the right, so that on reaching the fixed point at the top of the figure the flange of the wheel on that rail will already have been brought into the right position to pass it, whether on one side or the other. In 58 three-throw points are shown diagrammatically. Here more than one set of points are introduced at the same spot, and a train coming from the right may be sent in any one of the three directions. Neither of these devices are suitable for main line traffic, but are often useful in station yards where the space is confined.

Safety Points. These are points maintained by means of a weight or spring in such a position as would send a train or engine, etc., into safety when approaching them as facing points. In order that the train or engine, etc., may be sent in the alternative direction, someone must lift the weight or release the spring. There are many situations where this device is useful; it is often provided for sidings lest



60. CROSS-SECTION OF CULVERT

the trucks therein be blown by wind or otherwise brought on to the main line by accident.

Design. Points and crossings are critical parts of the permanent way; they are subject to special wear, and must be specially designed and supported. The great majority of railway accidents are due directly or indirectly to defects in their parts. The approximation of the sleepers has already been shown in **34**. The actual dimensions of the metal contained in the frogs and switches depend upon the section of the rail in use, the gauge of the line, and other circumstances. A junction or crossing may have to be effected at very different angles.

One line may be straight and another curved, or both lines may be on the curve, and they may be curving in the same or in the opposite direction, introducing trigonometrical problems of some complexity.

A Turn-out. In **59** the simple case of a turn-out from the main lines is exhibited diagrammatically. Here G represents the gauge of the railway in feet, R the radius of the curve by which the turn-out is effected, and A the angle of the crossing; L, the distance in feet between the springing of the curve from the main lines and the centre of the crossing, is called the *lead*. The following relations are immediately obvious:

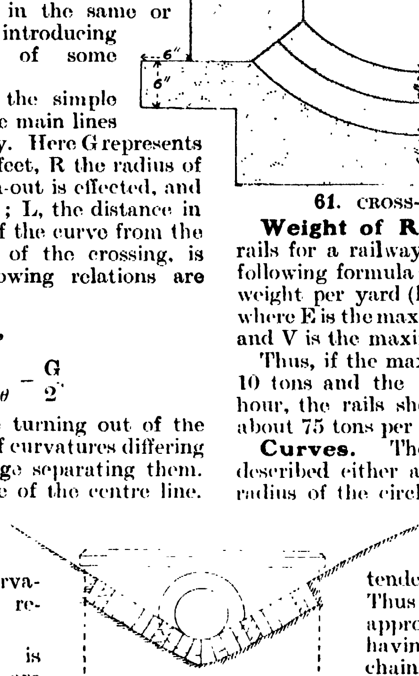
$$L = G \cot \frac{\theta}{2},$$

$$R = \frac{G}{1 - \cos \theta} - \frac{G}{2}.$$

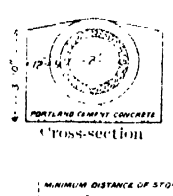
The two rails of the line turning out of the other have, of course, radii of curvatures differing by G, the width of the gauge separating them. R is the radius of curvature of the centre line.

A convenient form for expressing the lead is $\sqrt{(R_1 + R_2)G}$, in which R_1 and R_2 are the radii of curvature of the two rails respectively.

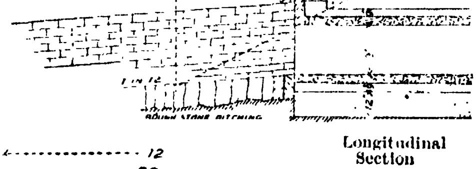
In the foregoing, it is assumed that the points are placed at the springing of the curve and are themselves curved to the proper radius; also, that the lines of the frog are also curved. These conditions rarely obtain except in street railways when curves are sharp; consequently, in careful work the fact that these portions of the turn-out are straight lines must be taken into account. It is, perhaps, well to point out that considerations of space have caused the curves in **59** to be drawn very much sharper than they would be made upon the main lines of an ordinary passenger railway.



End Elevation

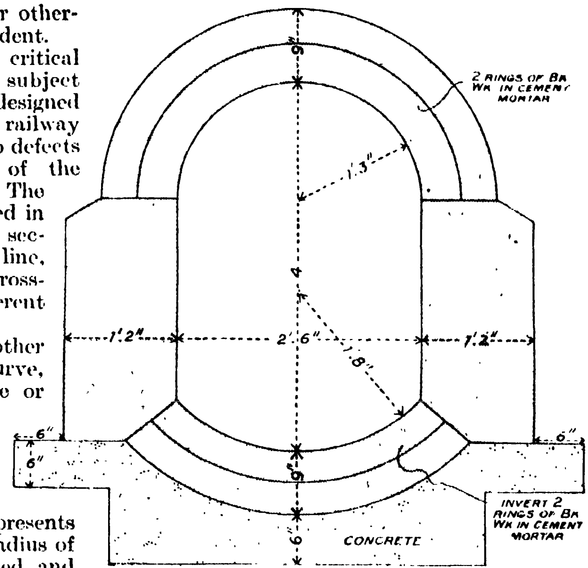


Cross-section



Longitudinal Section

62. SMALL CULVERT



61. CROSS-SECTION OF CULVERT

Weight of Rails. The proper weight of rails for a railway may be calculated from the following formula:

weight per yard (linear) $= 17 (E + \cdot0001\, Ev^2)^{5}$

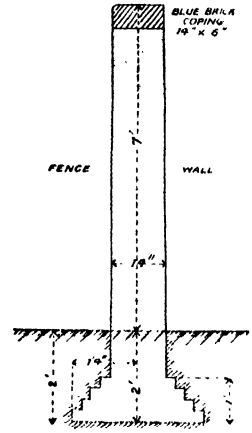
where E is the maximum load on one wheel in tons and V is the maximum speed in miles per hour.

Thus, if the maximum load on one wheel were 10 tons and the maximum speed 40 miles per hour, the rails should weigh 87 lb. per yard, or about 75 tons per mile of single line.

Curves. The curves of a railway are described either according to the length of the radius of the circle of which they form part of the circumference, or according to the angle at the centre of the circle which is subtended by a chord 100 ft. in length. Thus a 6-degree curve would be, approximately, the same as a curve having a radius of 955 ft., and a 15-chain curve would be, approximately, the same as a 5 deg. 44 min. curve. The amount of curvature is usually referred to as so many degrees per mile of line – that is to say, the total number of degrees circumscribed divided by the length of line circumscribing them.

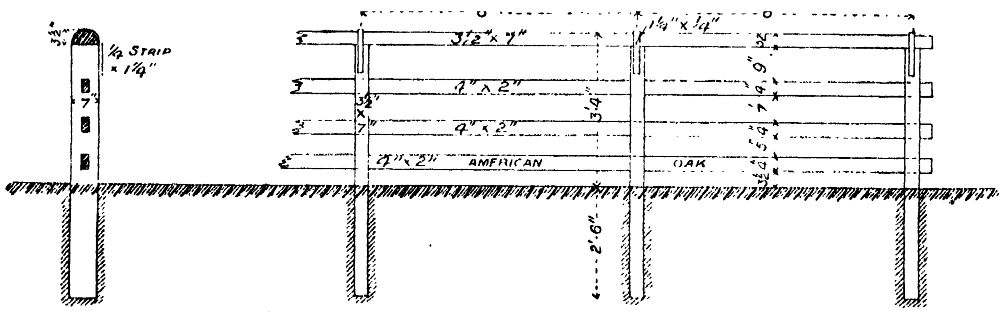
Friction on Curves. The extra wear and resistance to traction due to curvature is of course greater on a sharp curve than on a comparatively flat curve, but the length of the latter is proportionately greater, so that the aggregate effect of the curvature is governed by the magnitude of the sum of the central angles

of the curves about which the rails are turned. Curvature to the amount of 600 degrees per mile would have the effect of doubling, approximately, the resistance to traction; it would indeed offer about the same resistance to traction as an incline of 1 in 100, and be very much more objectionable—first, because the resistance would be the same both ways; secondly, because the wear would be much more both on rails and wheel tyres.



64. SECTION OF WALL

The interaction of tyres and the rails will be best understood by referring back to 37. The surface of the former, which comes into contact with the top of the latter, is called the *tread*. This is always shaped in the form of a cone. The coning is slight, and not sufficient to be very obvious, but, were the surface of the treads to be extended, a double cone would be formed, having an apex on the outer side of each wheel and in line with the axle. Hence, when running upon a straight portion of the line of way, the wheels will tend to take a central position, with each flange clear of the rail. When running upon a curve, the flange of the wheel on the convex side of the curve will be scraping against the side of the wheel, except so far as this is modified by *superelevation*, which will be explained later. The effect of the wheels being fixed to the axle and thus necessitating the slipping of one of them an inch for every degree of curvature, has already been dealt with in treating of the wear of the rails and length of the rails. This effect is in some degree modified by the coning of the heads, since the portion of the tread in contact with the outer rail is rather larger in diameter than the portion of the tread in contact with the inner rail, and will therefore move further than



63. COMMON TYPE OF POST AND RAIL FENCE

the latter during a given number of revolutions. Thus on a curve of about half a mile radius there would be little or no slipping from this particular cause. There remains, however, another result of curvature of the line, and by no means the least important. All road carriages have a *locking* arrangement, as it is called—that is to say, the axle upon which the two front wheels are attached, and to which the shafts, or, in a motor-car, the steering-gear is fixed, is movable about a vertical axis. It is sufficient to point out here that the absence on railway trucks, etc., of anything equivalent to the locking apparatus of a road carriage, causes on curves exactly the same amount of scraping and friction with the road as would result from turning a corner with an ordinary four-wheeled vehicle when the locking was jammed fast. While passing round a curve the carriages of which a train is composed form angles with each other, and on any change of curvature or reversion to the straight the buffers of the carriages—when lightly coupled—grind against each other.

In modern railway design, the numerical results of the effects of curvature upon the capital and annual expenditure is carefully calculated.

Superelevation. According to the first law of motion [see Physics], a train will continue to move on in the same straight line until acted upon by a force sufficient to divert it. On reaching a curve in the line this force is supplied by the pressure of the outer rail of the curve on the flanges of the outer wheels of the train, save as hereinafter explained. It is, of course, undesirable that all the pressure should be provided by pressure on one side of one rail, when by raising the level of the outside rail of the curve sufficiently above that of the inside rail of the curve the needful pressure would be exercised by both rails, and upon their upper surface.

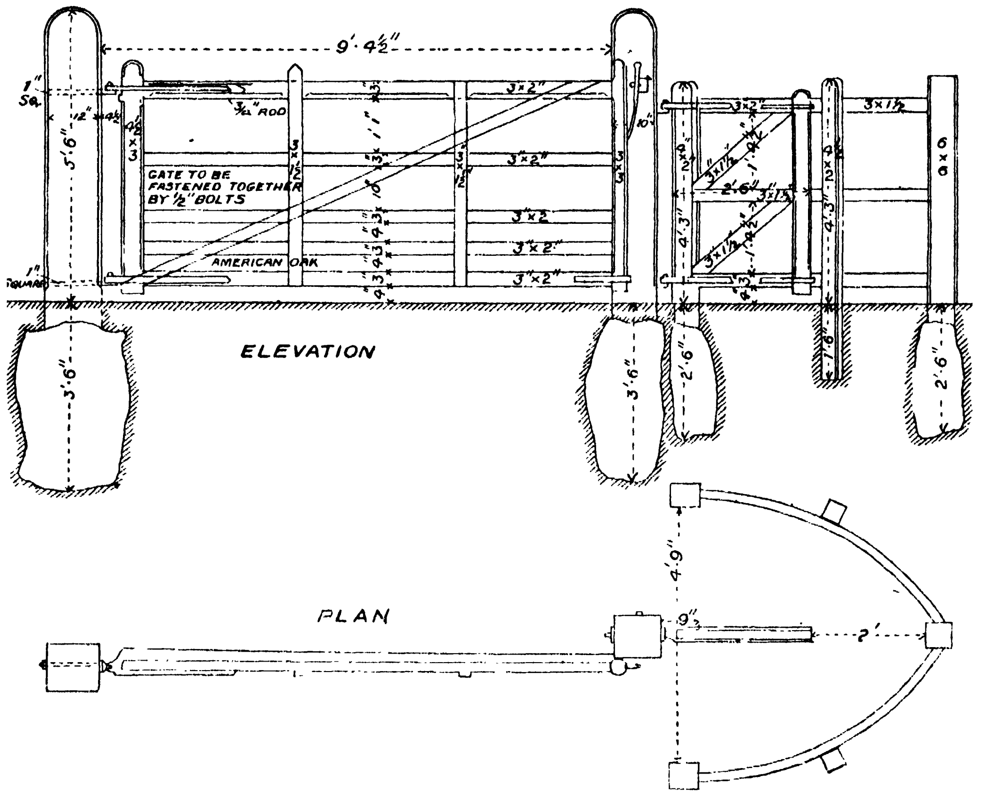
The outer rail of the curve should, therefore, be raised sufficiently that the component of the force of gravitation in a plane parallel to that of the rail-tops shall suffice to divert the path of the train to the degree required by the curvature. The amount by which it is raised is called the *superelevation*. If all trains moved round a curve at the same rate the superelevation could be calculated to fulfil perfectly the conditions above set out, so that the wheels would pass with their flanges equidistant from the rails, as before explained. However, all trains do not move round a curve at the same rate, so a compromise must be adopted according to the traffic conditions. The application of elementary mechanics

will show the superelevation for a line of standard gauge to be $\cdot 4 \frac{V^2}{R}$ in feet, where V is the speed of the train in miles per hour and R the radius of the curve in feet. Of course, on curves with an up grade the average speed, and therefore the superelevation, will be less, and where trains are to pass in both directions another compromise must be effected so that superelevation only partially counteracts one source of friction upon curves.

Transition Curves. So far, it has been assumed that the curves of a railway line are throughout the arcs of circles. Now, a circle is a curve of uniform curvation; immediately a train or, rather, a pair of wheels, enters upon a circular curve, it begins to turn, and continues to turn at the same rate until it passes out of that curve. The superelevation ought, therefore, to be as great at the beginning as at any other part of a circular curve. This is seen in the form of the expression for it already given. $\cdot 4 \frac{V^2}{R}$ depends only upon the speed and the radius of curvature. But the outer rail cannot be suddenly raised 4 in. or 5 in., as the case may be, at the tangent point where the curve begins, or similarly depressed at the end of the curve. The superelevation must, therefore, begin before the curve and be increased upon the curve, being there too much and here too little, and causing a lurching of the train very unfavourable to steady running.

Obviously, therefore, the right thing to do is to begin the curve at tangent point with a circle of infinite radius for which the superelevation would be nothing, and continue it by reducing the radius of curvature and at the same time increasing the superelevation, until the desired radius of curvature and its proper superelevation were gradually attained. The mathematics involved in such procedure is complicated, and though tables have been computed by the help of which transition can be made in this manner, it is more usual to introduce a short cubic parabola between the circular curves and the straight portions of the line wherever required for the safety of the service, or for the comfort of the passengers.

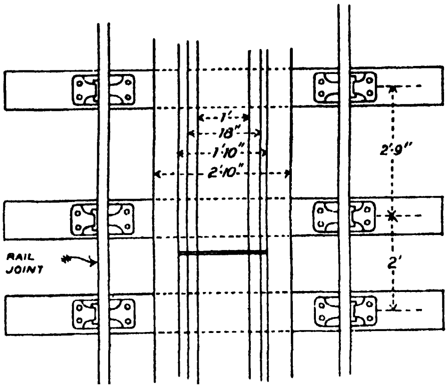
See the articles on Surveying for the means to be adopted to lay out a cubic parabola.



65. GATE AND WICKET FOR LEVEL CROSSING

Waterways. The bridging of rivers and brooks is dealt with in another article. It remains, however, to treat with exceptional rainfall. This is not conspicuous in our favoured islands, but most countries at intervals of 10 years or 20 years (or oftener in the Tropics) are subject to storm-bursts, etc., when water appears in places which are at all other times dry, in quantities

sufficient to demolish long stretches of railroad unless provision has been made to deal with them. To this end the character of the rainfall, the soil, and the area drained must be examined. The question to decide is: How much of the rain falling on one side of the railway must pass it to the other side and in what time? An inch of rain in 15 minutes is, of course, a very different thing to an inch of rain in an hour, since the latter has four times as long to run away. A porous soil will soak up a lot of rain, whereas a clay soil will allow nearly the whole of it to run off; and the same thing will occur on porous soil if a storm-burst occurs after a rainy period when the soil is saturated. If the drainage area stretched away from the railway a long distance, the water from it will arrive in more manageable amounts than if it were all within a short distance of the railway.



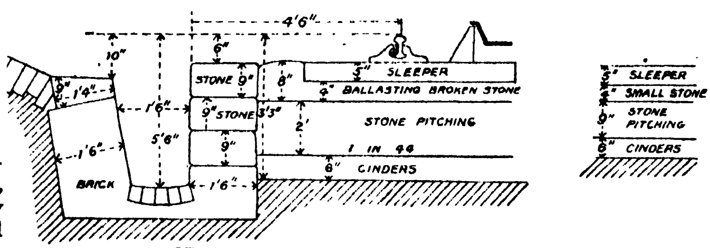
66. PLAN OF RAILWAY WATER TROUGH

Area of Opening. The first rough idea of what area of openings through the line will be needed to carry off flood water may be gained by applying the formula

$$A = C\sqrt[4]{S^3},$$

where A is the number of square feet required for the openings, S the area drained in acres, and C a constant quantity; to be taken equal to 1 or ·7 for steep, rocky localities, ·3 for rolling country, and ·2 or less where the drainage area stretches away from the line a distance five or six times its width.

If, then, the area drained were 10,000 acres of ordinary agricultural land the number of square feet of opening required would not be less than 200 ft. or more than 700 ft. This is a very wide margin in which to exercise judgment. In order to narrow it down it will be of great assistance if there are other roads near by the openings in which it may be examined and compared. If such openings have proved sufficient, the value of C implied by their size may be introduced with confidence in the above calculation. Marks left by the high water of previous floods should be carefully sought; in default of similar structures to go by, they will often serve as a guide to the maximum of water to be dealt with.



67. SECTION OF RAILWAY WATER TROUGH

Culverts. The openings in the line to allow for the appearance of exceptional floods like those for the bridging of small perennial streams, are called *culverts*. Cross-sections of these are shown in **60** and **61**. It will be seen that they are of brick, and substantially built, with a strong arch above to transmit the pressure from above, and an invert arch with concrete foundations to distribute the pressure over the earth below. In spite of the latter precaution it will frequently be found that the culverts in a high embankment have been bent downwards in the middle by pressure of the superincumbent earth. Smaller culverts may be built in the manner shown in **62**, where the end elevation and longitudinal section as well as the cross-section is shown. Culverts, particularly a culvert of circular section, as this is, may be permitted to run full or even with a *head* as a level of water higher than the height of the inside of the culvert on the up side is called. In general, however, it is best to make the culverts sufficiently large to prevent flood water "backing up" agains the railway bank.

Points about Culverts. It is in all cases important to preserve the embankment near the openings of culverts from the erosion of the water entering or leaving them. Thus, wing walls are often provided like those attached to ordinary bridges, but on a smaller scale. In **62** the culvert is shown provided with a flat face, and a channel of stone pitching sloped at 1 in 12 and 12 ft. long, is built at the down end to carry away the water rapidly and safely. The culvert itself should have a slope of 1 in 20. Cast-iron pipes are also useful for small culverts, and those too defective to carry water under pressure are often good enough.

A culvert may sometimes be economically roofed with old iron rails placed contiguously. Indeed, there are a great many uses about a railway to which old sleepers and iron rails may be put.

The earth on each side behind the walls of a culvert must be rammed hard and not tipped loosely over it to be consolidated by time and the weight of more earth on the top. Thorough ramming, as described, will relieve the culvert itself of much pressure and serve to sustain it against the tendency to curl beneath the weight of the bank as it settles. If the crown of a

culvert be allowed to approach too near formation level, there is sure to develop a bump which will be very perceptible as an engine passes above it, and which once established is most difficult to cure. The crown of a culvert should, therefore, be kept 3 ft. or more below the formation level.

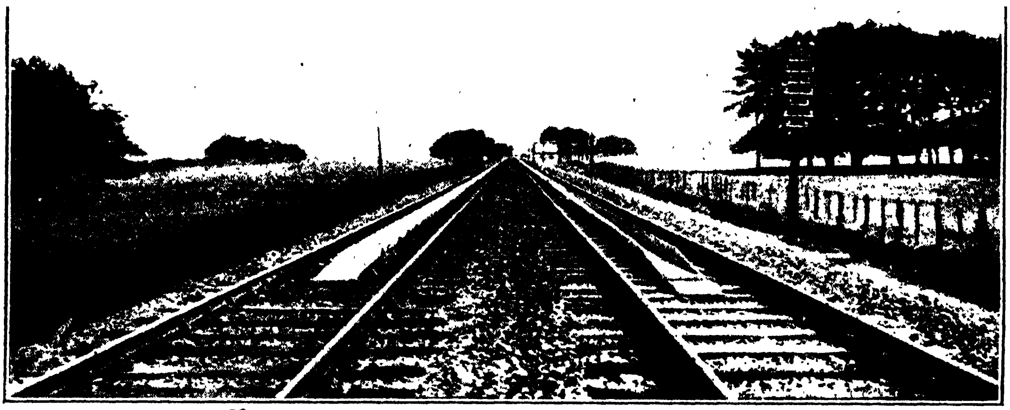
Fencing. A well-grown hedge forms the most economical fence where the soil, etc., is suitable, but it takes some time to grow. Supplemented by barbed wire to prevent trespass it makes a very satisfactory boundary. Innumerable other forms of fencing are in use. A common type of ordinary post and rail fence is shown in **63**. When a wall is necessary, the dimensions given in **64** are necessary and sufficient.

It frequently happens that gates must be provided in the fence to enable farmers' carts, etc., to cross the line. A common example is shown in **65**, in which a side wicket is introduced for foot-passengers. It will be noticed that the gate-posts are squared only above ground and the timber beneath is left in the rough. This gives the post a better hold on the ground, and provides a better defence against decay. The wood under ground should also be charred. If the timber below ground is not left rough, charring will weaken it unduly, and the post in this case should be creosoted, as sleepers are. A stout fence may be constructed of old sleepers where these are available. The sleepers of a standard gauge railway being 9 ft. long permit of a fence 5 ft. 6 in. high, 3 ft. 6 in. being under ground. Old rails may also be turned to account in like manner, though there are generally other more useful purposes to which they may be put.

Water Supply. The water consumed in locomotive boilers is a very variable quantity, and depends chiefly upon the work done by the engine. On down grades it will be small, on up grades it will be high, and heavy trains will involve a consumption greater than light trains, by an amount roughly proportional to the difference of weights, supposing that the same length of line is under consideration and the speeds are about equal. Fifty to one hundred gallons per mile are the usual limits, and stations for water supply should be provided at intervals not greater than 16 miles for the lightest traffic, and as close as 10 or 8 miles on roads over which the traffic is heavy. The general question of water supply may be studied in another article.

Track Troughs. On lines where a quick service is necessary, and long distances must be accomplished without a stop, troughs containing water are placed upon the sleepers between the rails. Passing trains are fitted with a scoop which enters the trough while moving and lifts sufficient water to enable the engine to proceed. Illustrations of such a trough are given, the plan in **66**, and half-section in **67**. The accompanying photograph [**68**] shows graphically the section of a railway line with two water troughs. Such troughs are usually placed in cuttings where a natural supply of water can be obtained by gravitation.

By the action of the scoop a great deal of it is spilt over the line, and special means must, therefore, be taken for the drainage of the permanent way in these places. The half-section in **53** shows how this may be accomplished. Two feet of stone pitching is provided beneath the ballast, and 6 in. of cinder below the stone pitching where the troughs are placed, while at the side is shown the diminished thicknesses provided for other parts of the same cuttings. Since the surface of the water in the troughs is necessarily level, the rails are made to slope from the commencement of the trough, so that the scoop enters the water automatically. It is made to leave the water by the same means. As to the quality of water required for locomotive boilers it does not differ from that required for other steam-using purpose.

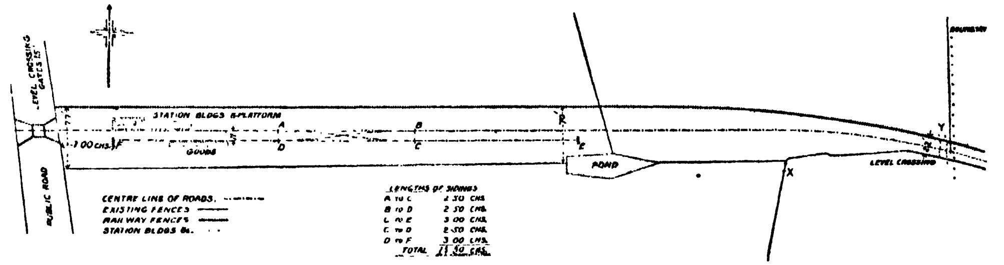


68. SECTION OF RAILWAY LINE WITH WATER TROUGHS

Water Tanks. The water tank on the tender of a locomotive may contain 10 or 20 tons of water, and tanks by the wayside from which the former are to be supplied must be dimensioned accordingly. They should be placed 8 ft. 6 in. from the centre of the nearest track, and about 12 ft. above the level of the rails. It is sometimes necessary

to provide for the injection of steam to prevent freezing, but this applies with most force to the water troughs described.

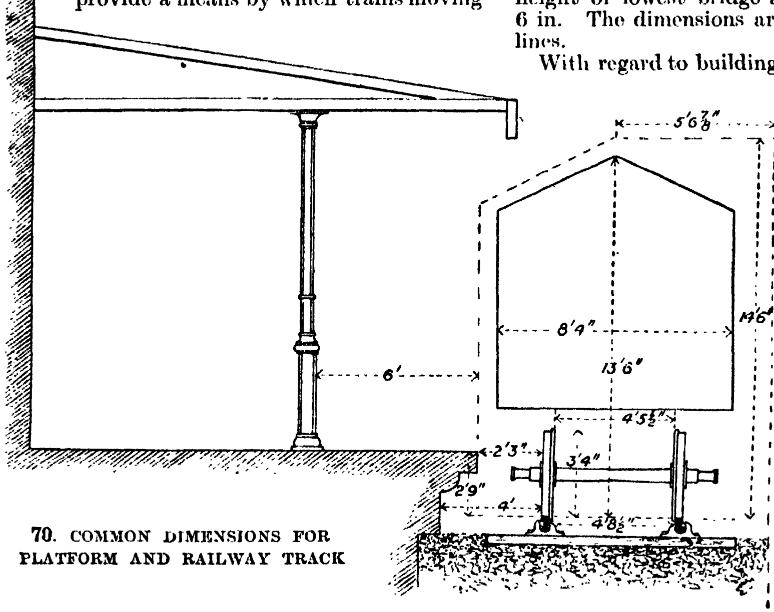
Stations. Large stations are usually situated in large towns, where the arrangements are always determined to a considerable degree by the configuration of the available ground.



69. A TYPICAL SINGLE LINE ARRANGEMENT AT A SMALL RAILWAY STATION

In 69 is shown the arrangement laid out for a wayside station of a single line of standard gauge railway that is in many respects typical. The sidings *c e* and *d f* are long enough to accommodate trains of 15 or 16 trucks, and land is provided to enable extensions to be made when and if they are warranted by future increase of traffic. The siding *c e* might be extended in the direction from *c* to *e* to twice its length, and another junction with the main line then made. This would probably be the first thing to be done, since it would provide a means by which trains moving in contrary directions upon the main line might pass each other with less delay; 11 ft. is the usual distance between the centres of adjacent lines of rails. The width of land taken up, therefore, suffices for two more sidings on either side of the lines of rails shown. The platform is most conveniently made 3 ft. high, measuring from the ballast, though it may be less.

Platform Structures. No structure upon the platform should be less than 11 ft. from the centre of the contiguous line of rails. Other distances commonly observed are given in 70. Here it will be seen that the ordinary width of rolling-stock for a standard gauge railway is 8 ft. 4 in., and its height above rail level 13 ft. 6 in. One foot is allowed between this height and that of the lowest structure under which it should be permitted to pass, which makes the least *headway* or height of lowest bridge above rail level 14 ft. 6 in. The dimensions are shown by the dotted lines.



70. COMMON DIMENSIONS FOR PLATFORM AND RAILWAY TRACK

With regard to buildings and other structures at the side of a line, none should approach nearer than 7 ft. to the centre of a line on which passengers are carried at heights above rail level between 12 ft. 6 in. and 11 ft., or, in the case of a goods line, nearer than 5 ft. 6 in. between the same heights. With other gauges and different rolling-stock these measurements will, of course, be modified, but the illustrations afford a concise notion of what has been found necessary and sufficient on lines of the English standard.

Continued

LIGHT RAYS & LIGHT PRESSURE

Rays of Light and their Characteristics. Magnetism and Light. Radiation Pressure. The Weight of Light on the Earth

Continued from page 3372

By Dr. C. W. SALEEBY

THE area which is affected by lupus, when exposed to ultra-violet light, slowly but with practical certainty heals. In marked contrast with the most successful results that can be obtained with ordinary surgery, the diseased tissue is replaced by a soft, pliable scar that can scarcely be distinguished from the original skin with which it is continuous, and that does not contract, whereas an ordinary scar by its contraction produces great deformity. While emphasising the splendid results which have been attained by the employment of ultra-violet light in the treatment of lupus, it is our duty to observe that this light has completely failed to exercise any favourable influence upon cancer, or upon various other morbid states of the skin. In this respect ultra-violet light has proved to be very much inferior to the Röntgen rays.

The Rays of Radiant Heat. We already know that just as there are rays beyond the violet so there are rays below the red. These, indeed, are none other than the rays of radiant heat. When sunlight is spread out into a spectrum, these rays also are sorted out into their places. If we place a highly sensitive thermometer in various parts of the spectrum, in succession, we can precisely ascertain their heating power. We find that the greatest heating power is exercised by a part of the spectrum considerably below the red, and that from this point onwards the heating power steadily diminishes, until at the violet end of the spectrum it has practically vanished altogether. The reader will compare these statements with the practical application of the Finsen treatment.

We clearly understand, of course, that these infra-red rays are related to the red rays just as a C on the piano is related to a D or an E above it. They are in every respect as real as the visible rays. The essential difference between them, from our point of view, is merely that our retinæ are so constructed that we can see the one kind but are blind to the other. In proof of this we may note that, just as there are Fraunhofer lines in the visible spectrum, so there are absolutely identical lines in the infra-red part of the spectrum lines or gaps where there is no radiation at all, and the explanation of which is identical with that of the gaps the presence of which can be detected by direct vision.

Light and Magnetism. Further aspects of spectroscopy are discussed in considering the chemistry of the stars [see CHEMISTRY]. Meanwhile, however, we must briefly consider a special aspect of spectroscopy which depends upon the relations between light and magnetism. In discussing this subject there is no choice but to use certain phrases the meaning of which cannot positively be understood until magnetism itself has been studied, but we shall reduce their employment to the smallest possible limits.

The relations between magnetism and light are of fundamental importance, and in considering the most important of them we cannot do better than quote freely from the words of Professor J. J. Thomson. He points out that "the first relation between magnetism and light was discovered by Faraday, who proved that the plane of polarisation of a ray of light was rotated when the ray travelled through certain substances parallel to the lines of magnetic force. This power of rotating the plane of polarisation in a magnetic field has been shown to be possessed by all refracting substances whether they are in the solid, liquid, or gaseous state."

It was natural that, having made this great discovery, Faraday should seek to see whether a magnetic field influenced the nature of the light emitted by any luminous body; but Faraday's apparatus was not adequate to bring him success. Ten years ago, however, a great advance was made by Professor Zeeman, of the University of Amsterdam. He found that spectral lines characteristic of lithium and of sodium were decidedly broadened if the flames containing salts of these substances were placed between the poles of a powerful electromagnet.

"Rays of Light in a Magnetic Field." Zeeman found that "in a strong magnetic field, when the lines of force are parallel to the direction of propagation of the light, the line (characteristic of cadmium) is split up into a doublet, the constituents of which are on opposite sides of the undisturbed position of the line, and that the light in the constituents of this doublet is circularly polarised, the rotation in the two lines being in opposite directions." On the other hand, "When the magnetic force is at right angles to the direction of propagation of the light the line is resolved into a triplet, of which the middle line occupies the same position as the undisturbed line: all the constituents of this triplet are plane-polarised, the plane of polarisation of the middle line being at right angles to the magnetic force, while the outside lines are polarised in a plane parallel to the lines of magnetic force." It is not possible here to go into the mathematics of this subject. Professor Lorentz has gone very far to explain the Zeeman effect, and his explanation is entirely in accord with the modern view of the structure of matter [see CHEMISTRY]. The interpretation of Zeeman's observation leads us to believe, first of all, that the bodies which produce the luminous vibrations which the spectroscope analyses

are negatively electrified. Secondly, the properties of such bodies closely correspond to those of the negatively electrified particles which constitute what are still called the *cathode rays*, and which we are now beginning to know as *electrons*. "Thus we infer," says Professor Thomson, "that the cathode particles are found in bodies even where not subject to the action of intense electrical fields, and are, in fact, an ordinary constituent of the molecule [the atom]."

Light Under Magnetic Force. But the Zeeman effect will teach us far more than this, though such a confirmation of the corpuscular theory of matter is obviously of the greatest value. It is found that magnetic fields influence light in a far more complex fashion than that hitherto described. Spectral lines are sometimes split up into sixes and nines as well as threes. This indicates that the lines in question must be due to the vibration within the atom of systems consisting of more electrons than one. This, of course, entirely coincides with the doctrines which we have advanced in the course on Chemistry, where it is shown that within the larger atoms there are sub-atoms, or systems of corpuscles, such as those which give rise to the helium atom when the radium atom disintegrates. Writing a year or two ago, Professor Thomson says: "Thus the behaviour of the spectrum in a magnetic field promises to throw great light on the nature of radiation, and perhaps on the constitution of the elements." Writing also about the same time, Dr. Knott said: "The general explanation of the phenomenon follows at once from Maxwell's electromagnetic theory of light, taken into conjunction with the obvious hypothesis that, in the molecules whose vibrations are the source of the radiation, there are electrical vibrations which will respond to a magnetic force brought to bear upon them."

Spectral Lines and the Theory of Matter. Professor Thomson predicted that the recent discoveries as to the relations between magnetism and light would help us to understand the constitution of the elements. This prediction has been abundantly verified. Ten years after his original discovery, Professor Zeeman was asked to show some of his famous experiments, and offer the most recent interpretation of them, before the Royal Institution. He then pointed out certain facts which we may here quote. He said that "the study of the spectral lines affords a most cogent support to the electronic theory of matter. Furthermore, it has long been known that in the spectra of many metals there occur certain series of related lines which show a correspondence in the various groups of metals. The lines which belong to different series show the difference between them by the fact that they always behave differently under the influence of magnetism, but the fundamental relation between lines of one series, occurring again and again in related elements, is shown by the fact that these lines behave similarly to one another under the influence of magnetism. We have already seen that some lines are separated into triplets, some into sextets, or sixes, and some into nonets, or nines. Now it is the fact that, in a group of elements, corresponding series of spectral lines show the same degree of resolution, whether into threes, sixes, or nines." In a word, the more intimately we study the Zeeman effect the further proof do we find of the relation between the elements, and the more nearly do we come to understand in what that relation consists. In short, we may say that the magnetisation of the spectral lines affords one of our very best clues to the inner structure of the atom.

The latest statement of the Zeeman effect, in the words of the discoverer himself, may thus be briefly summarised: Certain spectral lines are divided into three in a magnetic field when the lines of magnetic force are at right angles to the direction of propagation of the light. Of these three, the middle component is plane-polarised in one direction, and the two outer components in a different direction. If the lines of force are parallel to the direction of propagation of the light, similar lines are split up into only two components, which are circularly polarised in opposite directions to each other. Hence, it may be argued that, in a gas which is emitting light, the ethereal vibrations arise from negatively electrified corpuscles, the size of which corresponds to that suggested by the study of the cathode rays.

Charge and Mass. We have used the loose and popular term "size," but what physicists are really attempting to measure is the ratio of the electromagnetic charge of the electron to its mass. If for the electromagnetic charge we use the symbol e and for the mass the symbol m, then it is the value of $\frac{e}{m}$ that the physicist seeks to estimate. In the course on Chemistry we have discovered the great and important complication which is introduced by the movement of the electron. Lastly, we may repeat in the most recent words what has already been said.

In the spectra of many metals there occurs a number of related lines which are called *series*. All lines of one series are broken up by the magnetic field in the same way, whether into threes, sixes, or nines. Not only so, the extent to which the lines are broken up, the degree of separation between their constituents, is the same in all lines of a given series. The reader is, of course, able to understand that the splitting up of these lines in the spectrum is merely an indication of the production of waves of varying frequency or wave length. All that the spectroscope does is to sort out into a band all the vibrations that pass through it in proportion to their frequency. The splitting up of the spectral lines is thus merely an indication of the fact that a magnetic field is able, under certain conditions, to alter the vibration frequency and wave length of part of the light produced — this being doubtless accomplished by the influence of the field upon the oscillation or rotation of the electrons within the atoms of the luminous substance.

All the Facts Consistent. As we have seen, corresponding series of spectral lines in different elements—elements forming groups in Mendeleef's table of the Periodic Law—show the same type of resolution of the lines constituting the series, and show the same amount of separation of them. Hence it is inferred—and this is most important - that all the lines constituting a series of spectral lines are produced by one oscillating or rotating system of electrons within the atom, and therefore that the number of series of lines in the spectrum of any "element" indicates the number of oscillating or rotating systems contained in the atom in question; and, lastly, that in a group of related elements the oscillating systems giving rise to corresponding series of spectral lines are identical.

It is of some interest to notice that the amount of separation (due to a magnetic field) of the components of a spectral line is proportionate, as might be expected, to the strength of the magnetic field. This fact, curiously enough, affords a service for the student of magnetism. The most accurate means, and by far the most delicate, of measuring the strength of a magnetic field is to be found in measuring the effect of that field in resolving the spectroscopic lines in the light of some element made luminous for the purpose.

The Countless Number of Spectral Lines. We are in the middle of a subject which is of the greatest inherent difficulty, and which is still further complicated by its newness, and also by the number of its relations to other subjects. One of these is so very interesting that we must try to elucidate it—its interest consisting in its bearing upon the corpuscular theory of matter. Professor J. J. Thomson has lately laid down the proposition that the number of electrons constituting the atom of any element is strictly proportional to the atomic weight of that element; and, furthermore, that the actual number is not a large multiple of the atomic weight. Now, if this be so, as several lines of argument would appear to show, how is it that the spectra characteristic of various elements seem to display no limit to their complexity? How is it that the number of spectral lines is limited only by the measure of dispersion—the more complete our arrangements for dispersion being made, the greater being the number of spectral lines, while no signs of any limit can be detected? If we are to assume that each new spectral line demands the existence of another electron in the atom, we cannot possibly accept the proposition that the number of electrons in the atom is only a comparatively small multiple of the atomic weight.

Significance of the Spectral Lines. But Professor Thomson asserts that we cannot deduce the number of electrons in the atom from the number of spectral lines which we see when the light produced by the atoms of any given element is analysed. He assigns reasons for believing that a very large number of spectral lines do not indicate at all the internal structure of the atom, but depend upon the formation of new systems of electrons—of a more or less temporary and unimportant character—between certain of the electrons within the atom and their surroundings. On this theory it may be possible to explain the apparently infinite number of spectral lines.

We have still before us the great subject of colour and of the relations of various colours, as also the fascinating but exceedingly difficult study of colour vision. Then, also, we must discuss, in very considerable detail, the subject of polarisation, to which some allusion was made when we were discussing the history of our knowledge of light. Thereafter there will remain for our study various forms of ethereal vibration, such as the Röntgen rays, our knowledge of which is comparatively new, but which are of the very greatest importance and interest. Meanwhile, however, we must return, as briefly as possible, to a subject which is now coming to take a very important place in physics, and which is of the highest philosophic interest, since, though it may be studied experimentally in the space of a few cubic inches, it has to be reckoned with as a factor in the causation of many of the most stupendous phenomena of Nature.

Light as a Carrier of Momentum. When we discussed gravitation and the ether, we made some reference, apparently out of place, to the pressure of light. It was pointed out that this pressure exercised by light against any surface upon which it falls is really no more than an instance of a still more general phenomenon called *radiation pressure*. We observed that light must exercise a pressure if it be of the nature which Clerk-Maxwell demonstrated. It was further noticed that the figures for radiation pressure which Clerk-Maxwell arrived at, *à priori*, have lately been demonstrated to be practically correct in consequence of the *à posteriori* or experimental demonstration of radiation pressure by Lebedew and by Professors Nichols and Hull [see page 938].

The reason why we had to discuss radiation pressure in that place was that it is a universal or practically a universal force which, in its measure, is opposed to gravitation, since it acts in precisely the opposite direction. We commented upon the fact that radiation pressure compels us to modify our statements both of Newton's first law of motion and of his law of gravitation.

Radiation Pressure and a Moving Body. Here we must make some brief further reference to the subject; in the first place, because it is properly a part of the subject of light, or, rather, of radiation in general, and also because the work of Professor Poynting, to which we alluded on page 939, has since been discussed by himself at the Royal Institution. Experience has taught us that we are right in assuming that doctrines and speculations are fit for wide diffusion when they have reached the status of exciting an invitation to lecture in the famous theatre in Albemarle Street.

What is probably the most important contribution of Professor Poynting to the subject has been already referred to. It is the observation that a moving body, whether small or great, which is emitting light—or any other form of radiant energy—tends to crowd upon

the waves in front of it, while those behind it tend to be thinned out. The consequence is that the radiation pressure is greater in front of the body than behind it, and constantly acts as a break upon its motion.

Direction of Light and Sound Waves. Now, this case is, after all, only the latest illustration of a theory which goes by the name of *Döppler's Principle*, and plays an important part in many branches of physics. In describing it we cannot do better than quote the authoritative words of Professor Tait. The reader will see from them how this principle is applicable to waves of many different kinds:

"When a steamer is moving in a direction perpendicular to the crests of the waves, she will encounter more of them in a given time if her course is towards them than if she were at rest; while, if she be moving in the same direction as the waves, fewer of them will overtake her in a given time than if she were at rest. The same thing is true of sound waves. When an express train passes a level crossing at full speed, the pitch of the steam-whistle is higher during the approach to and lower during the recess from the listener at the gate than it would be if the engine were at rest. The successive sound-pulses are emitted at the same intervals as before, but from points successively nearer to or farther from the listener. Hence, more or fewer reach his ear in a given time. The principle is precisely the same as that of Römer's observation of the frequency of eclipse of Jupiter's satellites. The number of light waves which reach the eye per second is increased if the source is approaching, and diminished if it be receding."

Applications of the Principle. Döppler's Principle is usually described under Acoustics, and the usual acoustical illustration has been quoted above; but we have deferred its discussion until this place because it is of far greater importance in relation to light than it is in relation to sound. One of the earliest applications of the principle in the realm of light was made, as we have seen, by Sir William Huggins, who was enabled by its means to solve a problem which Comte, for instance, had declared to be necessarily impossible of solution throughout all time—*viz.*, the problem of ascertaining the motion of the fixed stars to or from the earth, or our motion relatively to them—in the line of sight. This problem might indeed appear insoluble, but Sir William Huggins has been able to ascertain, by the application of Döppler's Principle, the movements of stars which may be moving directly towards us or from us, and the light of which is constantly affected in wave length and frequency accordingly. Finally, we may quote the latest application of Döppler's Principle to the facts of light as made by Professor Poynting. Perhaps the best account of the principle, though not of its latest application, is to be found from the pen of Professor Poynting himself on page 51, vol. xxv., of the "Encyclopædia Britannica," ninth edition.

Reflection and Recoil of Light. Let us now return to radiation pressure and consider a few of its consequences and one or two of the facts which it may more or less certainly explain. From this point of view we have to consider light as a momentum carrier. Now, there are certain fundamental dynamical laws which have their application in this sphere also. We believe, for instance, that action and reaction are equal and opposite. If, then, when you fire a rifle, it kicks, there ought to be a similar back push or recoil when a radiant body fires off, so to speak, a train of light waves. The physicist knows, indeed, that this must be so. It is therefore extremely interesting to observe that, when Professors Nichols and Hull made their now celebrated experiments, they obtained just double the result in respect of pressure when the waves of light with which they experimented were reflected. In other words, these waves of light first of all exercised a pressure when they struck the surface and then gave it a kick as they were reflected from it.

75,000 Tons of Light. Professor Poynting has also studied the influence which light pressure due to radiation from the sun—or, to be more accurate, the whole radiation pressure from the sun—must ever be exercising upon the earth, with the consequence of tending to arrest its onward motion. This amounts to what at first sight would appear to be a formidable figure, the equivalent of the weight of 75,000 tons. But that this resistance to the earth's movement is trivial, and can have marked consequences only in the remotest future, will be evident if we consider that this push of the sun must be pitted against his gravitational pull, which is millions of times greater.

Various conclusions of importance follow from the fact that, whereas the force of gravitation varies as the mass of a body, the force of radiation pressure varies as its surface.

One extremely interesting speculation may just be alluded to. Professor Poynting has sought to apply the now demonstrated fact of radiation pressure to the problem which has been afforded astronomers by the rings of Saturn ever since Galileo discovered them 300 years ago—ever since, indeed, they caused him the utmost consternation by what looked like their disappearance, which threatened to throw discredit upon all his work. Professor Poynting has shown how it may be conceived that the rings of Saturn are formed of small particles derived from without and perhaps from the débris of comets. The attraction of such particles, but their arrest before reaching Saturn—which at that time, if not now, was doubtless a luminous body, the light from which exercised a very considerable radiation pressure—and their collection into rings which rotate around him, and into which the particles are sorted according to their size—all of these are capable, it would appear, of an adequate interpretation if the facts of radiation pressure are brought to bear upon them.

Continued

CARRIAGE TRIMMING

Trimming Materials: Their Uses and Methods of Attachment. Vehicle Linings and Hoods

continued from page 3181

By H. J. BUTLER

TRIMMING is confined to the passenger-carrying vehicles. We have, indeed, the padding of horse boxes, the various types of cushions, and back rests used by van and cart builders, and even tarpaulins and other waterproof covers, but, taking it as a whole, we do not find a trimmer's shop in a factory set apart entirely for vehicles designed to convey goods and merchandise. Many, especially those in the motor trade, talk of a body being "upholstered," but this is a term which is properly applied only to the furniture trade.

The Object of Trimming. Trimming has for its object the comfort of the occupants, by isolating them from the framework of the vehicle. It also decorates, a well designed lining and leatherwork skilfully carried out adding to the beauty of the carriage. Most of us have experienced journeys in railway carriages, and on the roof seats of trams and omnibuses, where the hardness of the seat causes considerable discomfort. Trimming remedies this.

Trimming is also frequently introduced where the passenger is seated on a set of springs apart from those applied to the body and under-carriage, thereby destroying vibration almost entirely.

In railway work we are familiar with the grades of comfort provided in different classes of carriages. First we have cushions with or without comfort for the back, and, as we pay more, we have pillar holders, elbow rests, floor coverings, and other details. In public service vehicles we have cushions inside, the modern electric tramcars being the most advanced in ministering to the comfort of passengers; while, no satisfactory means having been found to protect the cushions on roof seats during inclement weather, we find only aprons.

Road carriages of all descriptions constitute the chief outlet for the skill of the trimmer, not only in the cushions and linings, but in the covering of the wings and dashers, and in the construction of the folding head.

The highest degree of comfort is in the furnishing of American railroad cars. In these one may be seated in an armchair with reclining back and adjustable footrests. The Pullman cars running on the London, Brighton, and South Coast Railway are examples of the comfort provided on the other side of the Atlantic.

Trimming Materials. The trimmer has a large and varied stock of materials to handle. Woollen cloths of the best "West of England" quality are generally used in the darker colours, silk being employed for lining only in special cases, but finding favour as blinds in the form of lutestring. Satins and velvets we see only for carriages used on grand occasions, while plushes in various qualities find their way into the trimming of public service vehicles. Although the pile of plush is a receptacle for dust, yet the nature of the surface gives a firm seating. The coach trimmer is not fond of much pattern in his lining materials, generally preferring it quite plain, although in railway work we see more latitude in this direction. Underfoot we have Brussels, Wilton, and other carpets.

Leather and Leather Working. A fully qualified trimmer is not only a worker in cloth, but also an expert in leather working. The folding heads of landaus, victorias, and similar vehicles, the dashers, wings, and shaft leathers are places where leather is used. In some shops the qualification of the workman includes harness-making.

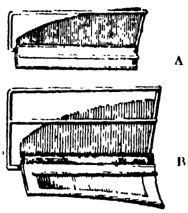
Bull hides are thicker and coarser than those of the cow, bullock hides being intermediate. Bull hides are used in harness-making and as border leathers for edging seat boards, while they are also divided into two layers, the hair or grain side being known as *bag hide*, and the flesh side being called *split*.

These split and bag leathers are japanned, a process whereby we obtain glasslike surfaces. This variety is used for covering the iron frames of wings and dashers, the japanned split being the cheapest. Similar to the japanned leathers but more elastic, are the enamelled hides. Here we find a material well suited for folding head leathers and aprons. Pigskin is used in the trimming of sporting and other carriages. It is to be recommended for its durability.

Apart from carpets there are other types of floor coverings. Kamptulicon and linoleum combine in some measure the qualities of carpet and oilcloth. They wear well, and are impervious to damp. The cheaper covering—floorcloth or oilcloth—is prepared on a groundwork of flax or tow, over which layers of paint are spread. Good linoleum may cost more than double the price of oilcloth, but it will wear at a moderate estimate more than four times as long.

Coach Laces. The ancient and universal art of weaving has produced in modern carriage laces beautiful trimmings with excellent wearing qualities. When we speak of lace in connection with coach work, the ordinary network of threads in various designs is not implied, but in this instance the term is applied to what might be called a wide decorated braid. In broad lace used for fronts of seat rails, glass strings,

and pillar holders, we have a woven material with the two selvedges averaging about $2\frac{1}{2}$ in. wide. Wide lace with a single selvedge is used for binding the edges of seat falls and pockets. Pasting lace has a single tape edge, and is used for hiding nail heads, the edge being nailed, while the remainder is folded over and pasted. It is used in varying widths for pockets, seat falls, and similar purposes. Seaming lace has two tape edges. It is used for concealing seams and for fixing linings which are sewn to it. Seaming cord is placed inside this lace when it is desired to give it a rounded form, the two tape edges being sewn together, and in this shape it is used for cushion edges, giving them a better and more lasting shape—a purpose it also fulfils in other departments of carriage trimming. Both seaming and pasting lace are comparatively narrow, the former running about $1\frac{1}{4}$ in. wide, and the latter about $\frac{7}{8}$ in. to 1 in. We can quite understand that the introduction of railways greatly increased the demand for trimmings generally, and for a time it was difficult for the manufacturers to turn out supplies of pasting and seaming lace sufficient to meet the demand. The introduction of the power loom solved the difficulty. Cloth and leather pipings are sometimes used instead of seaming lace.



56. DRIVING SEAT OF (A) A BROUGHAM AND (B) A BAROUCHE

Details and Stuffing Materials. There are also many small items that go to make up a luxurious interior. Laces with rose patterns are used to fix the top of the pillar holder to the pillar. A check-string of silk or a speaking-tube with a whistle and mouthpiece is provided to call the attention of the coachman. Then there are tabs and tassels for blinds, the guide line of silk on which the blinds ascend and descend, and the buttons and tufts whereby the stuffing material is kept in its place.

Stuffing materials, although not seen, must be of good quality, otherwise a lifeless cushion or flabby squabbing results.

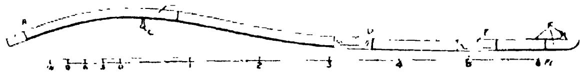
Curled horsehair, taken from the living animal, is in its best qualities unsurpassed for the retention of its elasticity. Flock, coconut fibre, shavings of bass and maple, moss, and even hay are used in cheap work. Lately the use of steel springs in cushion and lining work has been common, patent varieties being manufactured where each separate cushion or part of the trimming is made up on a wire frame to the size required, the special springs being firmly clipped into position and to each other.

Leather Stitching. The young trimmer has first to learn how to make his thread and then to acquire the skill to use it. The coach-trimmer does not use the bristle, but punches his hole in the leather with an awl having a diamond-shaped point, and then inserts his thread attached to a blunt harness needle. In a dash, he must have sufficient japanned hide to form a layer on each side, about $\frac{3}{4}$ in. being allowed for stitching and dressing off. During the operation of sewing the two layers of leather together with the iron frame between, the work is damped and tightly stretched with special pincers. Here there is disagreement between the older and the younger members of the trade regarding the respective merits of hand and machine work. Where there is a highly finished surface, as in a japanned leather, it must be admitted that a careful workman will often produce a better finish than a machine. After sewing, the work is pared off within $\frac{3}{16}$ in. of the stitches and the edges dyed, oiled, and polished.

The work on curved wings and front splashers requires more skill, and may be attempted after the straight work has been mastered. In best work we have the seat rail irons covered with leather, the join being made on the inside where it is least visible.

Seat Valances. The edges of driving and other carriage seats are, when exposed, finished with a border or valance [56]. In cheap work this may be simply of wood; the leather may be mounted on a wooden foundation, or stout border hide japanned on one side and blacked on the other may be used alone. The edges of the leather are welted or bound with enamelled leather, while the fixing of the border itself is hid by the beading placed over, and is retained by its shanks in the same way that a head leather is fastened to the pillar tops and elbow. A seat border not only decorates but it serves to retain the cushion in its proper position.

Head Valances. Similar to seat borders are head valances, used on the folding heads of victorias, barouches, sociables, and similar carriages. Their duty is to hide the joins of the head lining and leather, to finish off the head itself, and they should be fixed so as to prevent water from entering the vehicle when the head is up. A head valance is sometimes cut out in one piece, but may be joined at the corners or in the centre of the back. A bead finishes it, as in the case of the seat valance.


57. CARRIAGE SHAFT

A, Tip; B, Point; C, Tug stop; D, Breeching staple; E Kicking staple; F, Stop

Shaft, Pole and Bar Leathers. The shafts of carriages and carts have leather fixed at the point or front ends and at the kicking and breeching staples [57]. The sewing is done underneath, the herringbone stitch being much employed. Japanned split is used for this purpose. Oil leather known as *pole piece backs* is used for pole work. The stuffed pad is generally situated about 25 in. from the pole crab. Leather work is also in evidence on the splinter bar of a carriage. Here it is used at the bases of the roller bolt ferrules and washers on the bar to prevent the traces from chafing

the iron and woodwork. Similar material to that used in pole work is required, while the caps of the bolts may be ornamented with japanned split.

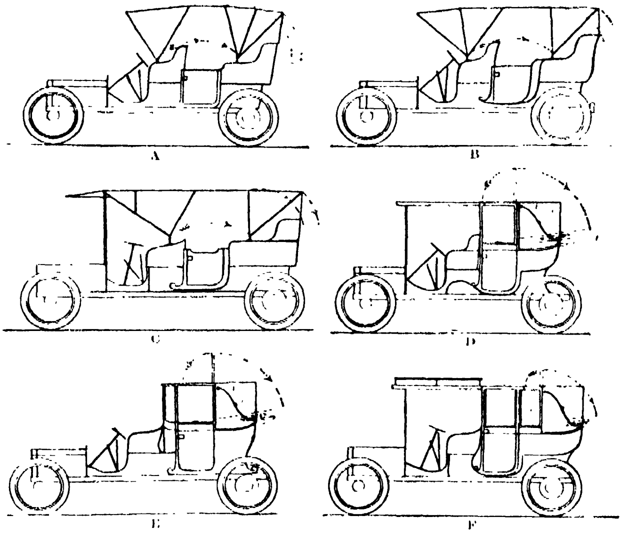
Aprons. Aprons are fitted to keep the lower limbs dry in wet weather, to add to the passengers' comfort in cold weather, and, in the case of the front inside seat of a sociable or barouche, to protect the front seat cushion and lining when not in use. It will be readily understood that however supple the enamelled leather may be, the appearance of the covering will be better preserved if, when the vehicle is not performing a journey, the aprons are opened out.

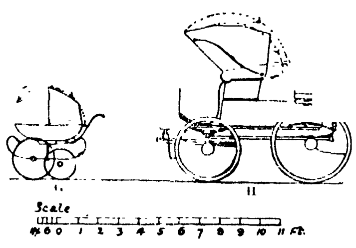
This remark, of course, applies also to the heads of landaus and victorias, and explains why we see them closed in the show-room and coach-house.

C-Spring Braces. C-spring braces are of vital importance in a carriage mounted on this type of suspension, and are made of oil leather similar to pole piece backs. A loop runs from the body connections to the top of the C-spring. Then the body of the brace continues round the back of the spring down to the jack where it is wound. Five inches is added to allow for attachment and adjustment at the jack, and allowance must be made for splicing.

Together with the distance twice over at the loop, we find a brace often requires 75 in. to be cut out of a width about ¼ in. wider than the spring. The brace is made of two thicknesses of leather and may be sewn with four rows of stitches, the inside rows being made to form a simple pattern.

Folding Heads. Of the leather work we have noted so far, none requires so much skill in fitting as the enamelled head leather, unless, perhaps, the moroccos and other leathers used in making linings. There may be three to five sticks in a head. The underside of the centre stick requires to be 3 ft. 8 in. from the seat board, and even 4 ft. in such vehicles as Stanhope and mail phaetons where the driving seat is protected. The top of the back or corner stick is usually thrown back 1 in. to 1½ in. from the square line of the corner pillar, and 3ft. 6in. to 4ft. is allowed, horizontally, from it to the front stick. The trimmer having placed his sticks in the proper position, they are temporarily held in position by webbing. Both lining and leather are made in four pieces, the former stitched to list, nailed to the front of the sticks, in the same way as inside roof coverings are attached. Many varieties of folding heads are shown in 58.





58. TYPES OF VEHICLE HOODS
The dotted lines and arrows indicate the position of the heads when folded, and the direction of the folding. A. Cape cart hood for entry motor-car, two sticks in front behind. B. Ditto, but three sticks in front and two behind. C. Ditto, but provision made for proper protection of the front glass screen. D. Motor single landaulette. E. Motor double landaulette. F. Motor limousine landaulette. G. Bassinette. H. Mail phaeton.

How the Trimming is Fixed. The squabbing is not all fastened directly to the proper framework of the body, but special pieces of wood, generally pine, are glued, canvased, and fitted to the quarters and other parts.

Sometimes it is necessary, owing to the shape of the vehicle, to fill up the hollow parts, and, apart from this, the trimmer should always work his materials so that no undue prominence is given to the work in the centre, otherwise the occupants will be rolled into the corner while travelling.

Construction of a Lining. Cushions and linings usually consist of two parts, the back of Forfar buckram, black linen, or other strong material, and the front, or trimming proper, of cloth or morocco, which, according to the squabbing and fulness of the stuffing, has to be made so much larger.

Having taken the interior measurements of the body, the canvas, roughed out to shape, is tacked in the body and pencilled round, then laid out flat on the board or bench and kept in position by pieces of iron covered with leather or other fixing.

Allowance for Fulness of Squabbing. The design of quilting, whether in squares or diamonds, is marked out, care being taken to do it accurately, otherwise a distorted trimming will result. The arrangement must exactly balance each side of a centre line in such cases as back squabs and cushions.

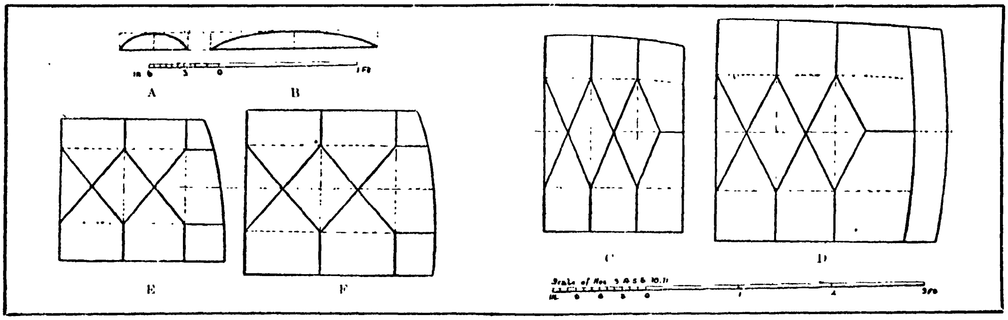
A diamond, when stuffed with hair, will stand up 1½ in. or so from the canvas. Knowing the

length of the diagonal marked on the canvas, we may estimate the size of the diamond on the cloth by drawing on a piece of paper and measuring with a piece of string [**59** A and B] a section of the stuffed diamond on each diagonal. This arrived at, the larger diamonds are marked on the back of the cloth. The stiffer the canvas, the less need be allowed for stuffing. The holes for the fixing of the button or tufts may be lined with calico to prevent tearing, and the folds of the pattern are ironed in the case of cloth and scraped when a morocco lining is used.

Door Trimming. In trimming a door, the work is kept as flat as possible. A quarter of an inch being allowed at the bottom above the rocker to allow for carpet, the border is made of 2½ in. broad lace finished off at the outer edge with seaming lace. Three-quarters of an inch would be allowed in this case for the fulness of the cloth.

with first, and the back row in cushions. In folding the diamonds, see that it is done downwards, so that in brushing the dust is not liable to work in. The marking out of a cushion is illustrated in **59** [E and F]. A morocco lining for a double brougham requires some 11 or 12 skins, a single brougham demands 10, and a victoria four or five, the provision of a cricket seat in the last mentioned bringing the total to six. There is about three square feet in a morocco.

Trimming a Double Brougham in Cloth. For a double brougham we require for a cloth trimming—roof 1¾ yd. (60 in. wide), the top and bottom of the back with fulness is allowed 1½ yd., the quarters (top and bottom) 1½ yd. for both sides, the hind body cushion 1¼ yd., the front ditto ¾ yd., the front squab ¼ yd., the front back ½ yd., the front quarters ¼ yd., and for the fronts of the seats inside the waste of the



59. MARKING OUT OF VEHICLE TRIMMINGS

A. Transverse section of a squab; the curved line representing the cloth, the base line the canvas. B. Longitudinal section of A. C. The marking out on the folded canvas for a bottom back squab. D. The above marking on the cloth. E. The folded canvas for a brougham inside cushion. F. The folded cloth for a brougham inside cushion

Bottom Back Trimming. In a bottom back, a convex curve is cut on the two sides to counteract the drawing-in of the cloth when stuffing. The design [**59** C and D] is worked folded in the centre, so as to obtain an equally balanced setting-out, and in an average brougham the canvas is about 36 in. wide by 26 in. deep, 1½ in. being left on the bottom, 1 in. at the top, and a full half-inch at the sides. The fewer the number of buttons used, the greater the freedom given the hair to use its elasticity. Also, an excess of buttons conduces neither to the comfort of the occupant nor to the beauty of the trimming.

The diamonds never finish right at the edge of the pattern. A distance of 6 in. is left on the edge of the cloth besides about 4½ in. for attachment.

Wadding is placed on the top of the hair to keep the latter from showing through the cloth. In making up, we must not forget that the pleats brush from right to left. The bottom back is bound with pasting lace sewn all round the edge. Seaming lace is fastened to the trimming rail bottom, to this is "frenched" or blind sewn the pasting lace on the top of the bottom back. The bottom row of buttons is usually dealt

above will suffice. Driving cushions, seat box, and fall are given 1½ yd., and the doors ½ yd. The roof brushes to the front (or an omnibus towards the door), the top, bottom back, quarters, and other parts brush downwards, while cushions brush forwards from back to front, front borders of cushions downwards, and sides as convenient. The box brushes as one piece of cloth.

The broad lace from the seat, up the pillar, along the roof across the back takes 4½ yd., the two doors 5¼ yd., the front of seats 2½ yd., the holder lace 2½ yd., hanging down 27 in. One pair of glass strings are 36 in. long, and one pair 24 in. Of seaming lace 40 yd. is required, of pasting lace 36 yd. Other necessities are: one pair of glass string guards, two gross of buttons to match the cloth, check string, 7½ yd. of buckram, ½ yd. of black American cloth (duck back), 3 curtains, 2¼ yd. silk (lutestring), 18 yd. silk curtain line, three triggers (acorns), one dozen ivory headed nails, four ivory buttons, four glass string slides, one pair metal door-pulls covered with morocco, 30 lb. horsehair (second quality grey hair, as the best quality is too hard), and 2½ yd. of carpet.

Continued

GHOSTS AND GHOST STORIES

PSYCHICAL RESEARCH
continued from page 358[illegible]

The Significance of Ghost Stories. Phantoms of the Living and of the Dead. Some Remarkable and Authentic Stories. What do they mean?

By HAROLD BEGBIE

THE process of modern science, which consists in "an interrogation of Nature, entirely dispassionate, patient, systematic; such careful experiment and cumulative record as can often elicit from her slightest indications her deepest truths," has never, in the contention of Frederic Myers, been applied to "the all-important problem of the existence, the powers, the destiny of the human soul."

What do the Legends Mean? It is because of her very *thoroughness*, because of her faith that the slightest indications of Nature speak often of her deepest truths, that psychical science has concerned itself with ghosts and ghost stories. The fact of ghosts may not be established; but the fact that there are legends of ghosts is a fact beyond dispute, and those legends, be it noted, are to be found in every race under the sun, and persist even in the most enlightened countries in our own day. What are their significance? What is the external fact of the stream of things hidden in their superstition?

Psychical science gropes among the obscure facts of human consciousness because she hopes to obtain from them that light upon the mystery of existence which neither mathematics nor geology, neither chemistry nor astronomy seems able to afford. She is persuaded that these legends signify something. She is assured that they have an origin and a meaning. She has never once professed her conviction that the fact of the legends existing is proof that the ghosts themselves existed; that would be unscientific, and would lead nowhere; she merely insists that as the legends exist, and exist so universally, they must have had some relation to fact, and what that relation to fact is she has set herself to discover. "Whether through reason, instinct, or superstition," says Myers, "it has ever been commonly held that ghostly phenomena of one kind or another exist to testify to a life beyond the life we know."

The Place of the Witch in Science. Already psychical science has laid many a ghost; but in this work she has not been only destructive—though destruction of superstition and error is admirable; she has been constructive as well. She has shown how it is people originally came to believe in these particular ghosts, and this revelation has meant a revelation of some of the workings of the human mind hitherto overlooked by the psychologists. Let us take the question of witches. Until recently we were justified in believing that legend exaggerated the powers, if not the very existence, of these people. To-day we understand how such people came to exercise so great a power over the minds of the populace. We can to-day produce in the minds of hysterical people precisely the same effect produced by witches. An hysterical woman, indeed, can create in herself, without any assistance from the hypnotist, ideas of the most extravagant and even terrible kind. The witch, then, is no longer for us a stupid myth or a devil-ridden sinner, but an hysterical woman of considerable interest to pathology, with some little power of hypnotism, which as much surprised herself as it terrified those who approached her.

The Two Kinds of Phantoms. In the same way we hope by a patient investigation of ghost stories to discover the pregnant fact behind their terrors and alarms. Instead of neglecting them, as psychology neglects them, psychical research investigates them patiently in the conviction that they must shed light on the problem of consciousness, even if they do not guide us to the desire of all knowledge. Psychical research has already progressed sufficiently far in her investigations to make a very sensible division of these ghost stories, a division of the living and a division of the dead. Ghosts have been seen of living people, and ghosts have been seen of dead people. We speak, therefore, of *Phantasms of the Living* and of *Phantasms of the Dead*. The very division is significant enough, and the intelligent student will easily see, when he has examined the general items of the first division, that the explanation of the first may in some measure be a form of the ultimate explanation of the second, a consummation eagerly desired apparently by the majority of people, since it would seem to buttress the good old sturdy conviction that the dead never return.

Phantasms of the Living. Ever since the dawn of history there have been cases of men and women seen by their fellows at times when they themselves were beyond the range of vision. Let us consider one case which came under our notice only the other day, and which may be taken as typical of all the cases under this head.

A lady, going upstairs, saw the nurse come from the bath-room, rubbing her hands together as if she had just washed them; the nurse was dressed in black bonnet, grey jacket, and white skirt; she did not turn her head on hearing her mistress, but passed on into the night nursery. Almost at the same moment a child in the nursery called to her mother asking her to tie a pinafore, and the mother replied that the nurse was in the night nursery and would attend to it. "No, mother, nurse isn't there; she's downstairs," replied the child, and at that moment the lady

saw the nurse coming up the stairs dressed in a manner entirely different from that which she had seen in her vision.

The lady is a woman of great practical commonsense, and she protests that she did not see a ghost, and does not think that she did, but she protests with equal earnestness her conviction that she saw the figure of the nurse at that moment as distinctly and as vividly as she ever saw it in real life

Seeing by Imagination. Now, the explanation of this apparition is comparatively simple, and will carry conviction to every mind except the mind of the lady. (It is a curious fact that it is far more easy to persuade people who have not seen a particular ghost that your explanation accounts for it, than it is to persuade those who have seen that ghost that the explanation of those people who have not seen it is the right one!) In this particular case it would seem as if the lady had on many occasions seen the nurse issuing from the bath-room after washing her hands; on this occasion her mind, working automatically, suggested to her a customary sight at the top of the stairs, and she, being more or less in a tired state of mind, received the suggestion and believed that she had actually seen the nurse. In that wonderful volume "Phantasms of the Living" the reader will be able to make himself acquainted with endless instances of this kind, and he will be able to form his own opinion on the working of the human mind. Nor need he be confused in cases where the apparition has been the forerunner of disaster, since the materialistic theory can explain this as the theory of telepathy. The anxiety of a mother in a moment of crisis is quite likely to affect the child so as to project the image of the mother upon the child's mind. There are many instances of this extreme form of sympathy operating in the case of twins over considerable distances.

But it will be seen that this theory, even though it lays ghosts in as wholesale a fashion as an expert skittle-player floors ninepins, reveals to us an operation of the mind as important to psychology as the attraction of the earth is important to physics. The trouble is that people, accepting the disproof of the ghosts, do not accept the proof of telepathy. They do not perceive that we have evidence here which endows the mind with powers of an extraordinary order, powers which lift it out of the category of material things, and bestows upon it at least a spiritual significance. In the article following this we deal with the question of Telepathy, but it is important to explain here the obvious and most suggestive conclusion that the only theory which accounts for phantasms of the living is one which concedes to the human mind faculties of an almost spiritual nature.

Phantasms of the Dead. We are now brought face to face with the supreme question of our subject. Is the evidence sufficient to convince the ordinary man that spirits have returned from Hades to visit these pale glimpses of the moon? Has the ghost of a dead person been seen by more than one credible witness long after the time of his decease?

Frederic Myers, who believed himself that this evidence is sufficient, concludes the seventh chapter in "Human Personality" with these words: "I do not venture to suppose that the evidence set forth in these volumes, even when considered in connection with other evidence now accessible in our 'Proceedings,' will at once convince the bulk of my readers that the momentous epoch-making discovery has been already made. Nay, I cannot even desire that my own belief should at once impose itself upon the world. Let men's minds move in their wonted manner; great convictions are sounder and firmer when they are of gradual growth. But I do think that to the candid student it should by this time become manifest that the world-old problem can now in reality be hopefully attacked; that there is hopeful and imminent possibility that the all-important truth should at last become indisputably known; and, therefore, that it befits 'all men of goodwill' to help towards this knowing with what zeal they may."

The Face at the Window. We will quote two stories of apparitions which seem to us inexplicable on the grounds of telepathy, and also so simple in their details as to convince the inquirer of their genuineness. The first story reached the Society for Psychical Research through the Bishop of Carlisle, and is related by the Rev. C. M. Tandy, Vicar of West Ward, near Wigton, Cumberland:

"When at Loweswater I one day called upon a friend, who said: 'You do not see many newspapers; take one of those lying there.' I accordingly took up a newspaper bound with a wrapper, put it into my pocket, and walked home. In the evening I was writing, and, wanting to refer to a book, went into another room where my books were. I placed the candle on a ledge of the bookcase, took down a book and found the passage I wanted, when, happening to look towards the window which was opposite to the bookcase, I saw the face of an old friend whom I had known well in Cambridge, but had not seen for ten years or more—Canon Robinson (of the Charity and School Commission). I was so sure I saw him that I went out to look for him, but could find no trace of him. I went back into the house, and thought I would take a look at my newspaper. I tore off the wrapper, unfolded the paper, and the first piece of news that I saw was the death of Canon Robinson."

In this story, it will be noticed, Mr. Tandy had not seen Canon Robinson for a number of years; there was no apparent reason why he should be thinking of him; no apparent reason why Canon Robinson should desire to appear to an old college friend; and no question at all of telepathic communication. The newspaper was in its wrapper, and the news of Canon Robinson's death had not reached his friend. No explanation in the world is possible for the apparition except the simplest of all—namely, that Mr. Tandy saw a ghost.

The Commercial Traveller's Story. The second story is pronounced by Frederic Myers to be "one of the best-attested, and in itself one of the most remarkable that we possess." We quote from a letter written by the subject of the experience:

"In 1867 my only sister, a young lady of eighteen years, died suddenly of cholera in St. Louis, Mo. My attachment for her was very strong, and the blow a severe one to me. A year or so after her death the writer became a commercial traveller, and it was in 1876, while on one of my Western trips, that the event occurred. I had 'drummed' the city of St. Joseph, Mo., and had gone to my room at the Pacific House to send in my orders, which were unusually large ones, so that I was in a very happy frame of mind indeed. My thoughts, of course, were of the orders, knowing how pleased my house would be at my success. I had not been thinking of my late sister, or in any manner reflecting on the past. The hour was high noon, and the sun was shining cheerfully into my room. While busily smoking a cigar and writing out my orders I suddenly became conscious that someone was sitting on my left, with one arm resting on the table. Quick as a flash I turned and distinctly saw the form of my dead sister, and for a brief second or so looked her squarely in the face, and so sure was I that it was she that I sprang forward in delight, calling her by name, and as I did so the apparition instantly vanished. Naturally, I was startled and dumfounded, almost doubting my senses, but the cigar in my mouth and pen in hand, with the ink still moist on my letter, I satisfied myself that I had not been dreaming and was wide awake. I was near enough to touch her, had it been a physical possibility, and noted her features, expression, details of dress, etc. She appeared as if alive. Her eyes looked kindly and perfectly naturally into mine. Her skin was so lifelike that I could see the gloss or moisture on its surface, and, on the whole, there was no change in her appearance otherwise than when alive."

The Mystery of an Unknown Mark. "Now," proceeds the narrator, "comes the most remarkable *confirmation* of my statement, which cannot be doubted by those who know what I state actually occurred. This visitation, or whatever you may call it, so impressed me that I took the next train home, and in the presence of my parents and others I related what had occurred. My father, a man of rare good sense and very practical, was inclined to ridicule me . . . but he, too, was amazed when later on I told them of a bright red line or *scratch* on the right-hand side of my sister's face, which I had distinctly seen. When I mentioned this my mother rose, trembling, to her feet and nearly fainted away, and as soon as she had sufficiently recovered . . . she exclaimed that I had indeed seen my sister, as no living mortal but herself was aware of that scratch, which she had accidentally made while doing some little act of kindness after my sister's death. She said she well remembered how pained she was to think she should have, unintentionally, marred the features of her dead daughter, and that, unknown to all, how she had carefully obliterated all traces of the slight scratch with the aid of powder, etc., and that she had never mentioned it to a human being from that day to this. In proof, neither my father nor any of our family had detected it, and positively were unaware of the incident, yet *I saw the scratch as bright as if just made.* So strangely impressed was my mother that even after she had retired to rest she got up and dressed, came to me and told me *she knew*, at least, that I had seen my sister. A few weeks later mother died happy in her belief she would rejoin her favourite daughter in a better world."

The Remarkable Features of the Story. In this story we have some remarkable features. In the first place, the subject of the experience is not a woman, not hysterical, not emotional; a commercial traveller attending to his business and smoking a cigar is not of the order of persons who usually see ghosts. The vision appeared nine years after the sister's death, and it wore the unknown feature of a disfigurement which had been made after death. Now, he would be a bold man who asserted that the mother unconsciously projected the vision of the daughter upon the son's mind. In the second place, we know of no case in which a person has projected the picture of another person on a distant mind. If it had been the mother who appeared to the son telepathy might be the explanation, but even here we should be puzzled to explain the apprehension of the vision on the son's part in the midst of his considerable occupation.

We have no room to quote further cases. We must ask the serious inquirer to consult the volumes of the Society of Psychical Research. Our contention is that while telepathy may explain many phenomena of this kind—and even then, be it most carefully noted, does but present the mind with a problem almost as wonderful as that of apparitions—it yet does not explain many cases in which perfectly trustworthy people have solemnly declared before men that they have seen phantasms of the dead a considerable period after the time of decease.

Messages from the Dead. We must point out, in conclusion, that the dead do not always *appear*, but very frequently—so far as the records tell—communicate by other means—*viz.*, automatic writing and through the mouths of mediums. The reader is not asked to believe all or any of these stories, but he is advised, before passing his judgment on the question, to consider whether all these obscure and somewhat alarming phenomena, if sufficiently investigated, are not likely to contribute some elucidation to the problem of consciousness, and, possibly, to throw light across the threshold of the Life beyond this phase of life.

Continued

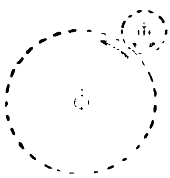
THE TURNERY & MACHINE SHOP

Screw Cutting. Gear Cutting. Turret Work. High-speed Tools. Templeting. Subdivision in the Shops

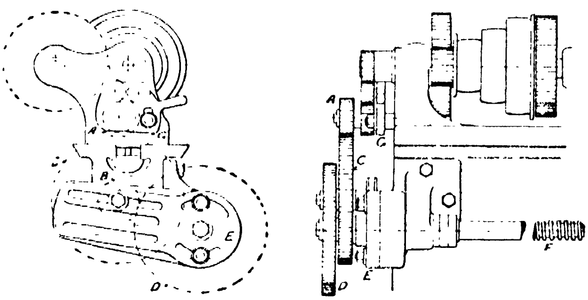
WORKSHOP PRACTICE
continued from page 3410

By JOSEPH G. HORNER

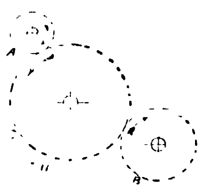
SCREWS are cut with dies comprising several cutters, or with single pointed tools. The latter are used in Fox, or chasing lathes, sometimes in the capstan lathe, and in the ordinary screw-cutting lathe. Either dies or comb tools are employed for bolt cutting, and for the formation of threads in capstan lathes. The screwing dies generally contain three cutters, in a cam plate operated by a scroll and lever. The plate is indexed for setting the positions of the dies, and fitted with an adjustable stop. Those dies are arranged with their cutting edges radially, so that they point to the centre of the work, no matter what its diameter. They cut a full thread at one operation. Bolts are largely done in the open-spindle chasing lathes. These are constructed, except for the open spindle, much like the ordinary hollow-spindle lathes. But the employment of an open spindle permits of the turning and chasing of bolts and screws with heads from the solid bar, and also permits of the ready chucking of single bolts and screws for chasing; while in stud turning the workman can pass his hand into the open spindle for the ready adjustment of the bar without going to the back of the headstock for the purpose. The centres of these lathes range from 6 in. to 10 in., those of from 8 in. to 10 in. being double geared.



289. SIMPLE TRAIN



290. METHOD OF GEARING UP CHANGE WHEELS



291. SIMPLE TRAIN CONNECTED BY IDLER

Long Screws. All bolts and short screws and studs made in quantities are produced by the foregoing methods, by dies, or chasers of some form or another, the guidance being embodied in self-leading dies, or in a hob which imparts longitudinal movement to the chaser bar. But what we have to consider here chiefly is the cutting of long screws by means of a single-edged tool, which is traversed in the slide rest by the lead or guide screw, at a rate which is predetermined by certain arrangements of change gears. The pitch of the guide screw is unalterable; the variable element is provided by the twenty-two change gears, which are capable of an immense number of combinations. They number 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120 teeth, with one or more duplicates, as 20, 40, 60, 80, 100. These derive their motion from the headstock mandrel or spindle which rotates the work to be threaded, and communicate it at equal or different rates to the guide screw. The only method which comes into rivalry with this, and that only in recent years, and to a limited extent as yet, is the formation of threads by milling cutters in what are termed *screw milling machines*. The difference is that the cutter in these rotates, and more rapid results are attained.

Methods of Calculation. In the common screw-cutting lathe the elementary basis of calculation between the guide screw, of fixed pitch, and the screws to be cut, of many pitches, finer, and coarser than that of the guide screw, is simply that of the *ratio*, or proportion which subsists between the two. As this takes the form of a fraction, the calculations are put in the same form.

The simplest way to consider this subject is to remember that three principal cases occur: (1) screws cut with pitches equal to that of the leading screw; (2) screws with pitches finer; and (3) screws of coarser pitches than that of the lead screw. The first class would be cut with wheels of equal numbers of teeth on mandrel and guide screw; the second with a smaller wheel on the mandrel driving a larger one on the lead screw, so *retarding* the movements of the tool; and the third with a larger wheel on the mandrel driving a smaller one on the guide screw, so *accelerating* the movements of the tool. Or, put in another way—which is of universal application—*the pitch of the guide screw is to the pitch of the screw to be cut as the number of teeth on the mandrel change wheel is to the number of teeth on the guide screw wheel.*

There are two practical methods of obtaining the change wheels necessary to cut a given thread: (1) by obtaining ratios direct, the other (2) by cyphers.

(1) To cut a thread of 2 per inch with a guide screw of 4 per inch

$$\frac{4}{2} = 2.$$

The change wheels must therefore have a ratio of 2 to 1.

(2) Place the number of threads in the guide screw for a numerator, and the number in the screw to be cut for a denominator, and add a cypher to each to obtain the numbers of teeth in the change wheels:

$$\frac{\text{Guide screw}}{\text{Screw to be cut,}} \quad \frac{4}{2} = \frac{40}{20},$$

and wheels of 40, and 20 teeth will cut the screw required, and 40 will go on the mandrel and 20 on the guide screw.

Simple and Compound Trains. When two wheels only are used the train is a simple one [289]. But when ratios exceed 6 to 1 simple trains do not suffice, because one of the wheels would exceed the limits of the centres of mandrel and guide screw, or the size of the largest wheel in a set. Compound trains [290] consisting of four or more wheels are then used, but the ratios of drivers and driven remain unaffected.

If a screw of 20 threads per inch be wanted, the guide screw having two threads per inch, then:

$$\frac{2}{20} = 0{\cdot}10,$$

a ratio of 0·10 to 1, or $\frac{1}{10}$th; or, putting it in the form of a fraction:

$$\frac{1}{10} = \frac{10}{100}.$$

But as the lowest wheel in a set has 20 teeth, this fraction must be multiplied by 2:

$$\frac{10}{100} \times 2 = \frac{20}{200}.$$

But, now, 200 exceeds the highest numbered wheel in a set, and so other wheels must be found. There are several ways by which a compound train may be deduced, by breaking up into factors as follows:

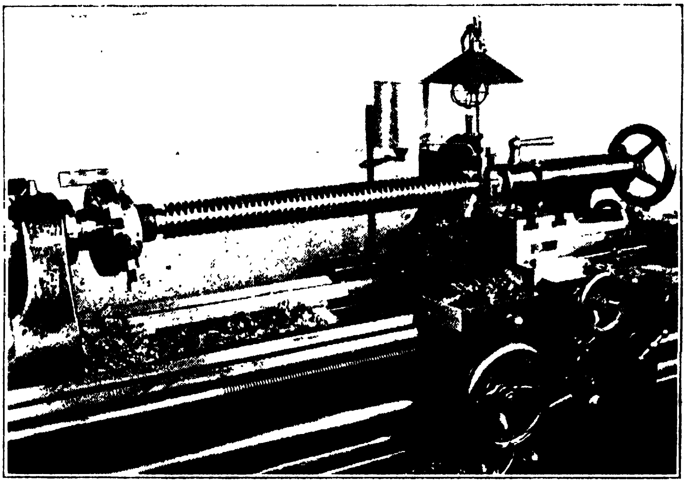
$$\frac{20}{200} = \frac{10 \times 2}{20 \times 10} = \frac{100 \times 20}{200 \times 100} = \frac{50 \times 20}{100 \times 100} = \frac{25 \times 20}{50 \times 100}.$$

These last factors give wheels in a set without requiring duplicates, and they have the same ratio as $\frac{10}{100}$ or $\frac{20}{200}$; and 25 and 20 are the driving wheels, and 50 and 100 are the driven wheels.

In the case of very fine or very coarse pitches, the compounding has to be increased to six or eight wheels; but the ratios must always be observed exactly. The final arrangements obtained can always be tested by multiplying together the drivers and the driven separately, and dividing one quotient by the other, as in the example just given.

It will be evident that, the object being to select workable wheels—that is, wheels in the standard sets—the breaking up into factors in the example given may be done by halving, or doubling, or adding, or lessening by any suitable increments, as fourths, fifths, or thirds. But the essential point is that the factors which stand for numerators and denominators respectively must be increased or diminished in the *same proportions* in order to retain the same *ratio.*

Gearing Up. Fig. 290 illustrates the method of gearing up change wheels. The driving wheels here are A, B, and the driven C, D. E is the quadrant, or swing plate pivoting around the axis of the guide screw F, the object of which is to afford a large range of adjustment for the centres of the change wheels. The first wheel, A, derives its motion from the mandrel through the fixed gears shown, the function of which is the reversal of the direction of rotation of the lead screw by the reversing plate G. Fig. 291 shows a simple train, A, B, connected by an idler, C, to cause the lead screw to rotate in the same sense as the mandrel, to cut towards the headstock. The photo 292 illustrates the cutting of a left-handed screw in the shops of Ludwig Loewe & Co.



292. LATHE CUTTING A LEFT-HAND SCREW

Fractional Pitches. Pitches often have to be cut which are not integral parts of the guide screw, but comprise integers and fractions. Then the denominator of the fraction is used as a multiplier, thus: $9\frac{1}{2}$ threads per inch to be cut with a lead screw of 4 per inch:

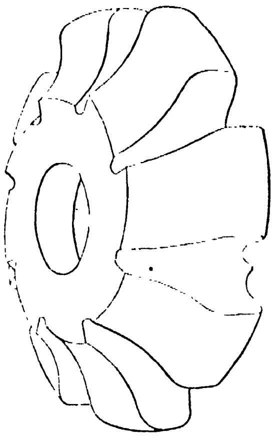
$$\frac{9\frac{1}{2}}{4} \times 2 = \frac{19}{8} \text{ ratio.}$$

We may multiply this by, say, 5:

$$\frac{19}{8} \times 5 = \frac{95}{40} \text{ wheels;}$$

and 40 will be the driver, and 95 the driven.

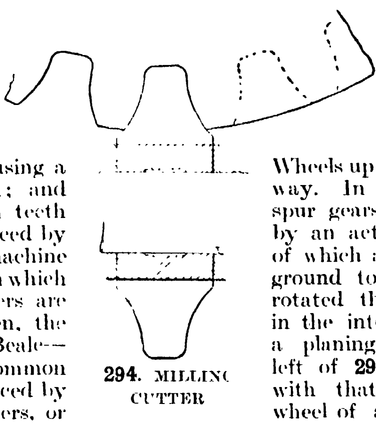
The foregoing simply give the principles on which screw-cutting calculations are worked out. Calculations may also be worked decimally. Millimetre pitches may be cut with an English lead screw by using a wheel of 127 teeth. The question of cutting screws having prime numbers to the inch often has to be considered. So, too, the problem often arises of cutting, not so many threads per inch, but of a certain number of threads in a given length of so many inches, and fractions of an inch, all of which admit of more extended treatment than can be given here. But no real difficulty need arise if the essential *ratio* between lead screw and screw to be cut, as previously stated, be borne in mind.



293. MILLING CUTTER

The cutting of multiple threads is done by chalking the teeth of the mandrel wheel and of the driven wheel which engages with it in two equal parts for double threads, in three for treble threads, etc., and using these marks as points at which to start each thread. There are also other devices. The question of catching threads at proper places has to be considered when the pitch of the screw to be cut is not divisible by that of the lead screw without a remainder. The cutting of square threaded screws gives rise to difficulties in grinding the angle of the tool, for which a diagram must be made of the developed thread. These and other details render screw cutting a highly specialised department of the turnery.

Gear Cutting. Recent years have witnessed an extensive substitution of cut for cast gears. There are many reasons for this into which we cannot enter. But with regard to the machine shop, the result is that the numbers of machines have increased, and that several new types have been designed. The most remarkable growth has been that of the *planer* type, using a *form*, or enlarged pattern tooth; and the *generating* type, in which teeth mathematically true are produced by mechanism embodied in the machine itself. These include machines in which rotary and reciprocating cutters are used—the Bilgram, the Warren, the Fellows, the Robey-Smith, the Beale—machines which have little in common except the resulting teeth produced by generation without either formers, or tooth shapes embodied in the cutters themselves.



294. MILLING CUTTER

Cutters. In the ordinary or older practice of gear cutting, all teeth are formed by milling cutters [293 to 295]. These answer very well for spur gears, though the accuracy of the teeth depends entirely on that of the cutters. But these are approximate only, since eight cutters have to produce all teeth from those of a rack to the smallest pinion in a set, and 24 cutters have to suffice in cycloidal teeth, as in the tables above:

INVOLUTE CUTTERS.
(*Brown and Sharpe System.*)

No. 1	will cut wheels from	135 teeth to a rack
No. 2	,, ,, ,,	55 ,, ,, 134 teeth
No. 3	,, ,, ,,	35 ,, ,, 54 ,,
No. 4	,, ,, ,,	26 ,, ,, 34 ,,
No. 5	,, ,, ,,	21 ,, ,, 25 ,,
No. 6	,, ,, ,,	17 ,, ,, 20 ,,
No. 7	,, ,, ,,	14 ,, ,, 15 ,,
No. 8	,, ,, ,,	12 ,, ,, 13 ,,

EPICYCLOIDAL CUTTERS.

Cutter	A	cuts	12 teeth
,,	B	,,	13 ,,
,,	C	,,	14 ,,
,,	D	,,	15 ,,
,,	E	,,	16 ,,
,,	F	,,	17 ,,
,,	G	,,	18 ,,
,,	H	,,	19 ,,
,,	I	,,	20 ,,
,,	J	,,	21 to 22 ,,
,,	K	,,	23 ,, 24 ,,
,,	L	,,	25 ,, 26 ,,
,,	M	,,	27 ,, 29 ,,
,,	N	,,	30 ,, 33 ,,
,,	O	,,	34 ,, 37 ,,
,,	P	,,	38 ,, 42 ,,
,,	Q	,,	43 ,, 49 ,,
,,	R	,,	50 ,, 59 ,,
,,	S	,,	60 ,, 74 ,,
,,	T	,,	75 ,, 99 ,,
,,	U	,,	100 ,, 149 ,,
,,	V	,,	150 ,, 249 ,,
,,	W	,,	250 or more
,,	X	,,	Rack

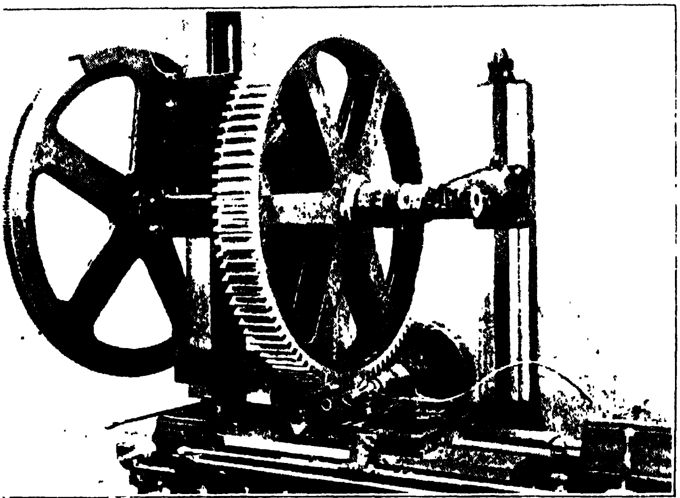
For tl ifferences in teeth, see the course on Drawing for Engineers.

In some of the Gleason machines a form is used as a guide for the roughing-out planing tool, A in 296. As this leaves fine ridges on the teeth, finish is imparted by the tool B, the shape of which is the counterpart of the tooth spaces. Wheels up to 20 ft. diameter are cut in this way. In the Fellows' machine, used for spur gears only, the teeth are generated by an actual wheel [297, A] the teeth of which are hardened, backed off, and ground to form cutters; the wheel is rotated through a small arc, and cuts in the intervals of each movement by a planing action, as indicated to the left of 297. This process is identical with that which would happen if a wheel of a hard substance were rotated in relation to a wheel blank of a plastic material. One wheel thus generates the teeth of any wheel of any size of the same pitch with perfect accuracy. In 297 the right-hand illustration shows a pile of wheels, B B B, arranged to be cut simultaneously. At C, below, an internal gear is being cut. The gears B are being tooled with a draw cut, hence the reason for the resistance afforded by the adjustable stop D above.

Cutters for Bevel Wheels. But the difficulties in cutting bevel wheel teeth with rotary cutters are far more serious than those which occur with spurs, because of the tapering forms of the teeth, due to the attempt to cut teeth, the sectional shapes of which change constantly, with rotary cutters of unalterable section [**298**]. The result is a compromise. Absolutely true teeth are impossible in this system, hence the reason for the employment of planing and generating machines.

In planing machines for bevel wheels, a *form*, or enlarged tooth about three times larger than the wheel teeth on the major diameter, is used as a guide to the arm which carries the reciprocating cutting tool, which travels in a path always towards the apex of the pitch cone [**299**]. The result is teeth the accuracy of which depends on that of the form used. The process is a slow one, hence many of these machines have two arms and tools cutting on opposite flanks. The Sellers, the Oerlikon, the Gleason, and the Greenwood and Batley belong to this group.

The first generating machine made — the Bilgram — embodies roll cones by which the reciprocating arm is coerced, and accurate teeth are thus generated, and this machine still holds a leading place. The Robey-Smith embodies a rather complicated link mechanism by which the movements of the two cutting arms are controlled. In the Warren, the tools are controlled by slides, the angles of which change constantly.


295. MILLING CUTTER CUTTING SPUR GEAR

The duties of the machinist operating gear-cutting machines obviously vary very much with the class of machine used. In the ordinary types the pitching has to be done by hand through a division plate and change wheels; in the fully automatic types one man or youth can attend to several machines. The turning of the blanks is done elsewhere at the lathes, or in some cases they are milled. The wheel blanks, turned to the correct outlines, terminating at the points or ends of the teeth, are also bored. The bore affords the means by which they are held on an arbor during cutting, though they are fixed [**295**] firmly by bolts in addition.

Turret Work. The large group of machines which are included under the terms *turret lathes* and *automatic screw machines* constantly grow in importance. They are rivals to the common lathes and to screwing machines. The essential feature by which they are distinguished is that, instead of setting a tool or tools in succession in a slide-rest, a number of tools are fixed up and set permanently in turret and cross-slide [**301**] to operate in succession on a piece of work, and that the operations on any number of similar pieces are repeated without any refixing or readjustment of the tools. This means that all the dimensions of a piece of work are fixed by the tools, with the result that tentative measurements during the progress of the cutting are avoided. This is true in turret and automatic lathes alike. But the latter embodies, in addition, all provisions necessary for the automatic movement and gripping of the work, of the rotation and locking of the turret and its tools, and of the tools in the cross-slides, and all are timed to take place at the precise instant required.

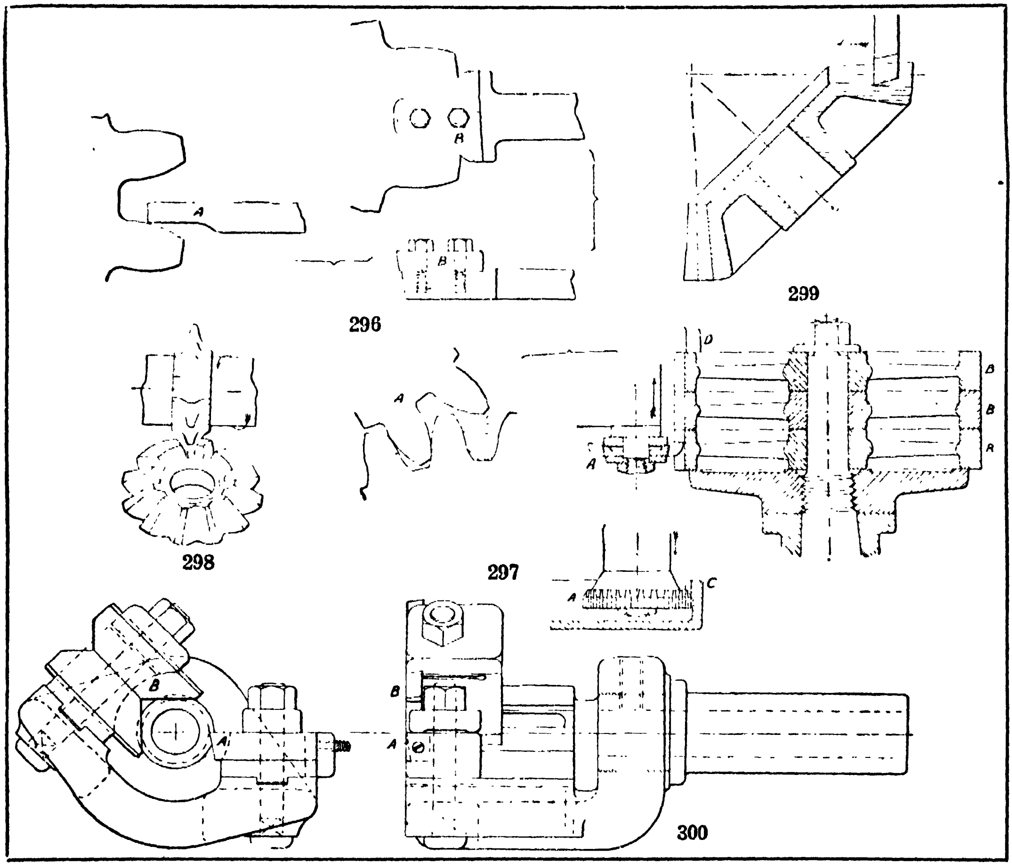
Turret Tools. Tools used in turret practice comprise roughing and finishing tools for turning, boring, and forming; tools for cutting-off, drills, reamers, and screwing tools. They are gripped in the turret directly, or in intermediate boxes, or in the cross-slide. No measurement is ever taken with rule or calipers after the tools are once fixed up until after the work is removed from the lathe. The range of movement of each tool is predetermined by the use of stops and throw-out mechanism, so that subsequent gauging detects but a small proportion of inaccurate pieces. The action of the tools is much assisted by the free use of lubricant pumped under pressure on the tool points and the portions of the work which are undergoing cutting. Their cutting edges are thus preserved good for very considerable periods, generally for some days, and the accuracy of the work produced is not impaired by any important rise in temperature.

Points in Turret Practice. In the employment of these tools there are several other matters which have to be borne in mind as affecting the accuracy of results—the embodiment and the maintenance of alignment, the prevention of vibration or distortion, the flexure of tools and their holders, and the synchronising of the movements of the tools

with those of the work are essentials. It must be remembered that, in the interchangeable classes of products which are done on the turret lathes, uniformity in dimensions is necessary within a finer limit than a thousandth of an inch, and therefore flexure, distortion, or vibration to that amount would be fatal to the degree of accuracy demanded in such work.

The multiplication of tools is the most distinguishing feature of the turret lathes. Instead of putting in and clamping tools in a rest one after another for performing successive operations, all the tools required are held in a revolving turret and on a cross-slide [301], so that they may be brought into position in succession as rapidly as possible, and by means of stops may be checked at predetermined positions, enabling work to be repeated indefinitely to uniform dimensions. The tools are constructed so that they cannot cut smaller or larger through any mistake on the part of the attendant, who simply has to move the handles to feed up and withdraw the tools. In automatics even this is dispensed with, and the movements are actuated by cams without human intervention.

A great improvement introduced by the turret lathes is that of making pieces from solid plain bar, instead of using forgings of the approximate shape required, and finishing them. By using a bar, a considerable length can be gripped in the chuck and fed through at intervals as pieces are turned off, and there is no bother with scale as on forgings, or difficulty in holding up to dimensions. Bars up to 6 in. diameter are thus worked from on semi-automatics and full automatics.



296. Gear cutting with form as guide 297. Details of Fellows' gear-cutting machine 298. Rotary cutter at work 299. Bevel gear cutting by planing 300. Box tool for turret lathe.

Example of Turret Work. The example of turret practice shown in **300** to **306** will serve to illustrate the principal operations done with turrets, the case being taken from the practice of Alfred Herbert, Ltd. on one of their automatics. The piece being produced is a locomotive handrail pillar, which is finished from a bar, A, the size of the largest diameter, held in the headstock chuck and rotated by it. The turret, shown with its complete set of tools in **302**, first brings up a starting tool, B, with three flat cutters held in such a way that the end of A is bevelled or pointed, as seen in **302**, to enable the box tool C [**303**] to begin easily. Before, however, C can

begin, B has to retreat, and the turret be given a partial turn, bringing C into line with the bar, when it commences to travel up the latter. The box tool, seen in detail in **300**, comprises a cutter, A, held in a cast-iron frame or box, and clamped and adjusted therein by a bolt and grub screw; and a pair of adjustable V-guides [B] located opposite the cutting edge. The bar cannot, therefore, spring away from the tool, as it may in ordinary turning, but is kept up to it by the guides, enabling heavy cuts to be taken and ensuring uniform diameters on numerous pieces. Two diameters may be turned on a bar by fitting a couple of the tools and guides A and B in a box, one behind the other, a longer box being used if required.

Returning again to the sequence of operations, in **304** the box C has retreated, and another, D, is brought up for finishing to exact size—because C had to rough off a large amount—and also to cut down the end of the bar smoothly to length, with a facing tool held in the shank of D. Forming is the next operation, done with a broad, deep tool [E, **305**], held on the cross-slide and fed into the bar until it assumes the shape seen in **305**. A steady bush, F, in the turret supports the end of the bar during forming, to prevent it from springing back under the heavy stress. Screwing is done next with the die [G, **306**], which cuts the thread as the bar revolves, and then automatically opens, upon which the turret moves back, avoiding the necessity for unscrewing the work out of the die, which would have to be done if the latter were solid. Finally, the piece is parted off with a cutting-off tool [H, **306**], formed so that the globular form of the pillar end is retained, leaving a mere tit at the end. When the pillar drops off, the bar is fed through the spindle again, and the cycle of operations is repeated.

In addition to these common operations, others which can be done on turret lathes are boring, recessing, and threading holes, broad facing, with tools travelling on the cross-slides, taper turning and boring, reamering, knurling, etc., some of which entail the use of special rigs.

Influence of Turret Work. The modern practice of turret lathes and automatics has effected profound changes in the forms of and methods of operation of many cutting tools. From the comparatively simple forms used on the semi-automatic lathes, in which all the various movements of the tools and of the work are effected by the volition of a workman who dares not move away from his post, they have grown into very complicated mechanisms. The reason of this complication is twofold: first, the desire to be able to perform two or more cutting operations simultaneously; and, secondly, the economical necessity of making the machines and their movements wholly automatic. The result is the evolution of the boxes that contain several tools. The movements of each tool are predetermined, and in the more elaborated types there is mechanism introduced for producing movements of the tools in the boxes, independently of the primary motion of the box derived from the movement of the turret.

High-speed Tools. The advent of the high-speed tool steels in 1900 has changed the practice of the machine shop in a more radical fashion than any other innovation since the inventions of the slide rest lathe and the planing machine. These steels do not owe their value to carbon, as do the ordinary tool steels, but chiefly to chromium, tungsten, and molybdenum. They are not tempered, but hardened right out in cold air. They operate best at high speeds and at high temperatures. They show to better advantage in turning mild steel than cast iron. They are forged at a white heat, which would ruin ordinary carbon steels. The rate of cutting varies with the area of the chips removed. It ranges from, say, 40 ft. or 50 ft. a minute doing very heavy work, to 400 ft. on light cuts. From 800 lb. to 1,000 lb. of chips removed per hour is no unusual record. One result is that new lathes have been designed to withstand the enormous stresses imposed, and that the driving power in machine shops using these steels has had to be trebled and quadrupled. The same steel is used largely for drills and milling cutters, and some remarkable performances are on record.

301. REVOLVING TURRET AND CROSS SLIDE

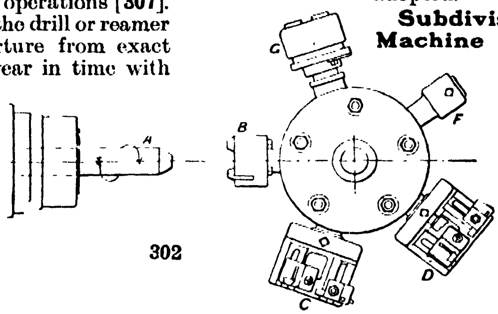
Templeting. A section of modern practice which is of vast and growing importance is that denominated *templeting, fixture,* and *jig work.* The terms are used rather loosely, but may be defined as follows. A *templet* or *template* is used to avoid the lining out illustrated in a previous article. Its function is either to embody centres and edges for lining off work by, or to be employed as a guide for machining by. The first-named is the templet proper, the second is often termed

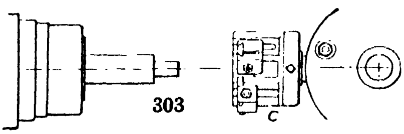
a *fixture*, something which is attached to the piece of work, or vice versâ, thus obviating any lining out whatever. The advantage is that not only is much time saved, but any number of pieces machined thus will be all alike, which cannot be guaranteed when lines have to be worked by.

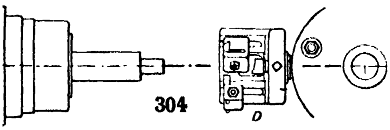
The simplest example of the templet, or jig, is that used for drilling and allied operations [**307**]. The holes provided in it control the drill or reamer so that there can be no departure from exact centres. As the holes would wear in time with the friction of the drill, they are generally bushed with hardened steel [**307**], or cast-iron bosses are screwed or riveted to the sheet metal templet [**308**]. Provision is also made for setting or adjusting the templet to the work, and this is often not an easy thing to design when fitting has to be made to rough castings and forgings.

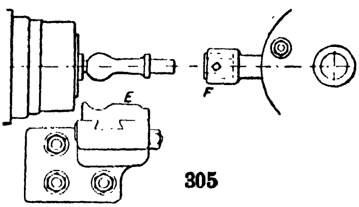
In strictness, the term templet, though applied loosely to fixtures and jigs, signifies something by which work is lined out, though drilling templets, as just shown, are constantly spoken of. A *fixture* denotes something which is specially designed and attached to a machine for holding special pieces in repetitive work without involving tentative settings. It may or may not include provision for controlling the movements of tools. But if it does embody such provisions, the term *jig* is usually applied. Some of these fixtures and jigs are of a simple character, others are extremely complicated and costly. Many embody provision for controlling the whole of the tooling on an elaborate casting or forging, as planing, milling, drilling, reaming, etc., at one or more settings. They may cost many pounds, but in an interchangeable system of manufacture the cost per piece becomes almost inappreciable, and often comparatively unskilled labour may be employed, since neither lining out nor measurement has to be done. In modern practice these devices are largely adopted.

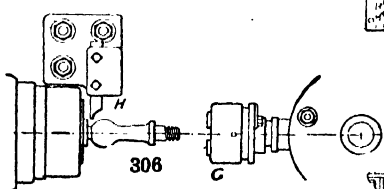
Subdivision in the Machine Shop. This is carried out to a greater extent than it was a few years ago. It is done in two ways—either by grouping machines under a single roof, or by arranging them in separate shops. In a works of medium size, the first is the better plan, but as firms increase in dimensions the latter possesses advantages. In the first case, the entire shop can be under the control of one foreman; in the second, since more than one foreman is necessary, it is better to keep the departments in separate buildings. It is more convenient for power transmission and for handling materials and work to have machines grouped, when in large numbers, in separate buildings. The modern method, therefore, is not to mix up all sorts and sizes of machines, as lathes, planers, shapers, drills, indiscriminately, but to have a heavy planing department, and a light one also, light milling machines distinct from the heavy, light drills also—a system which lends itself to the better control of tools and jigs, to the training of hands, and to economies in production.

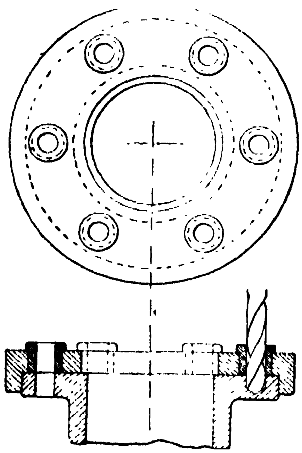


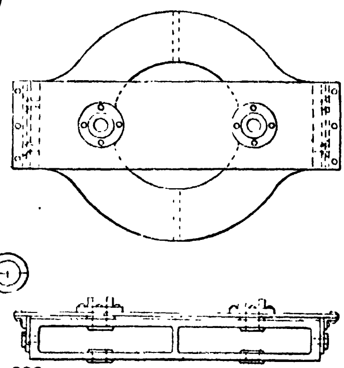












307. STEEL BUSHED JIG

302–306. TURRET PRACTICE

308. JIG WITH CAST-IRON BOSSES

Continued

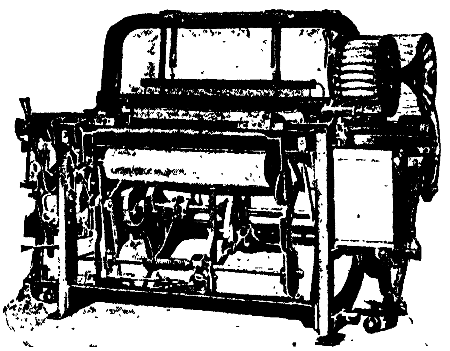
AUTOMATIC LOOMS

The Advantage of Continuous Supply of Weft. Efforts to Attain this. Automatic Weft Feed on the Northrop Loom

Continued from page 3383

By W. S. MURPHY

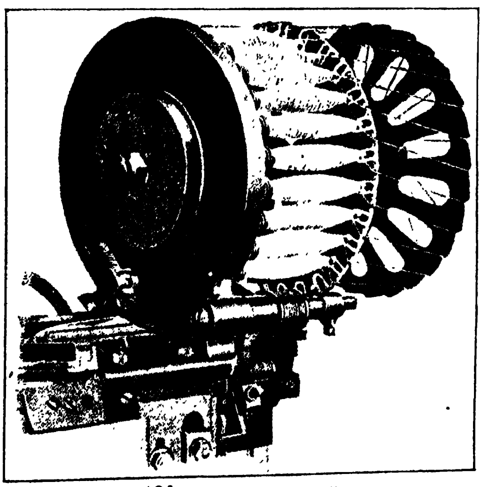
WHEN Edmund Cartwright invented the power-loom he imagined that he had discovered the principle of automatic weaving; but practical experience soon showed him his mistake. The loom itself would go on working so long as the driving power was applied; but the weaving ceased so soon as the weft spool in the shuttle was exhausted. Here the inventor met with an obstacle he could not surmount. The shuttle is not attached to the mechanism of the loom; it runs to and fro, an independent unit. To be refilled, the shuttle must be taken out; this involves a complete stop. We have also been compelled to devise means by which the loom is thrown out of gear when the weft breaks. Here is the problem: How is the loom to be kept going while the shuttles are being changed, or while the weft supply is being maintained?



163. THE NORTHROP LOOM

The Northrop Loom. After the lapse of 100 years, and after many a man had worn himself out with attempts to get over the difficulty, news came from across the Atlantic that the problem had been solved by a citizen of the United States. The solution took the form of what is now known as the *Northrop loom* [**163**]. Strictly speaking, the loom was a novelty only in the sense that it made commercially practicable what had before been regarded as experimental.

Continuous Supply of Weft. The main feature of the Northrop loom is the apparatus for the continuous supply of spools to the shuttle. It was originally intended to be made applicable to all forms of existing looms; but, as we shall see from our examination of the appliance, some modification of structure was necessary.



164. WEFT CARRIER

The bobbin or spool carrier [**164**] is placed on the breast of the loom. Two discs, the length of the spool apart, are sleeved on the supporting bracket, and on the inner sides of the discs are set small springs which hold the spools. A guard is formed on the supporting bracket to keep the bobbins in position, while the one nearest the loom, and in position for delivery, is constantly pushed by a spring pawl. On the boss of the disc is a ratchet which engages the spring pawl and regulates its action. Further out on the spindle bearing the spool carrier, we find another disc over which the thread from the spool is led, and held tense.

Spool. The spool of the Northrop loom is special [**165**]. In the tip is a little hole to fit on the spring of the holder; on the butt end grooves or rings are made to catch into the spring of the shuttle; and the spool must be fairly strong.

Shuttle. A common shuttle is solid, with an eye at one end for the threading of the weft; but the Northrop shuttle [**166**] requires to be of such a structure that it will allow a spool to be thrust into it by mere force, and yet hold it tightly. Inside, the shuttle is grooved, and a spring tongue grips on to the spool; at the end where the eye is required, a slit opens to admit the tensely drawn thread of the spool, and then closes with the motion of the loom.

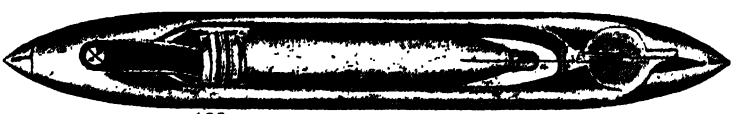
Mechanism of the Feed. We have seen the tools, but the most important parts are yet to be examined. In the ordinary loom, the weft fork stops the loom as soon as the thread breaks; this is the mechanism which the inventor of the Northrop has utilised for his purpose. Instead of the hammer and presser acting on the spring lever which throws the

belt off the driving pulley, they have a different function to perform. Connected with the slide at the end of the weft fork, we find a pair of rocking levers, one of which has on its end what is called a *feeler* [**167**], while the other acts on the spool carrier. By the combined action of these levers, the weft spool is taken from the carrier and driven into the shuttle.

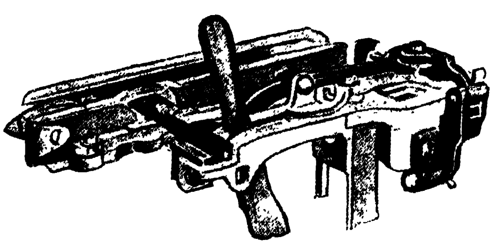
Control of Weft and Warp. When the weft is spent it leaves a trail of thread; to do away with this the Northrop loom is fitted with a cutting device which severs the thread at the edge of the cloth. Warp-breaking is also detected by another ingenious improvement on the usual warp-stop motions. It consists of a series of slotted steel slides in the healds, through which the warp is passed. If a thread breaks or slackens, the steel slide drops and stops the loom.

165. SPOOL OF NORTHROP LOOM

Working the Northrop Loom. Assuming that the loom is going and the weft laid properly in the shed, we find all the special mechanism of the Northrop out of action—the pusher is raised, the feeler is laid back, there is no contact between presser and shuttle box, for the weft fork tilts at every beat of the slay. But now the weft breaks, and the fork stands still; the hammer, hitherto beating the air, is met by the slide on the end of the fork, which it drives back, setting the other levers in motion. The lever controlling the shuttle feed is brought up, and is met by a small iron projection on the body of the slay. By this finger the lever is brought down, and the spool pushed out of the holder into the shuttle. At the same moment the spool drives out the spent or faulty spool, and threads its yarn into the shuttle. This action is clearly illustrated by **168**. As will be noted, it was the forward movement of the slay which called those motions into play; when the slay has swung back and reached its limit, the action is completed; before it comes forward to make another beat, the weft is in the loom, and weaving has been resumed. With the same act, the ratchet on the carrier gets a turn, and another spool is put into position. If, from any cause, the feeding apparatus fails to act, the loom stops. Every detail of this loom has been carefully devised, and covered by patents.



166. SHUTTLE OF NORTHROP LOOM



167. NORTHROP LOOM FEELER

The "Burnley" Loom. Though the best known of the automatic looms, the Northrop does not occupy the field alone. We do not refer to the Hattersley, and other looms of that class, which also have undoubted claims; but there is one rival, at least, based on the same principle as the Northrop, and this must be given some attention.

A cast-iron hopper, containing specially made weft-cases, is fixed on the breast of the loom. The bottom of the shuttle box is cut away, and beneath it a curved slot extending to the front of the slay has been framed. Two spring fingers are fixed in front of the mouth of the slot, and project towards the breast beam. At each side of the hopper a vertical slide is mounted, and these slides between them hold a cradle, which keeps the weft cases in position. Upon these slides the weft fork acts when the weft fails, causing a weft-case to drop down and into the mouth of the slot. At the same time, the position of the dropped case is occupied. When the slay comes back, the weft-case cannot obtain re-admittance to the hopper; it meets a solid resistance; therefore, it is driven through the slot and up into the shuttle from which it expels the spent weft-case. A weight brings back the cradle into its normal position.

The "Seaton" Loom. It has often been said that the shuttle is the thing which prevents the loom from being completely automatic. The inventors of the Northrop, the Burnley, and other looms less famous, have devised means of making the feed of the shuttle automatic; but others have tried to do away with the shuttle altogether. Reluctant as we may be to part with such a faithful servant of the textile industry, we confess to the belief that in this direction lies the complete solution of the problem. Of several devices already being tried, the loom known as the Seaton, seems most typical and promising. In this loom the shuttle is abandoned, and another contrivance adopted, which we must examine in detail.

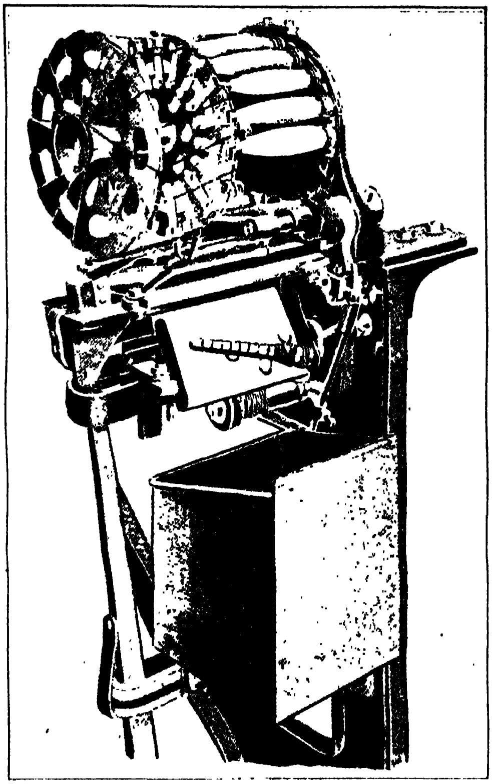
Weft Carrier. In the place of the shuttle, we find in the Seaton loom a double steel carrier, with grippers on each end. This carrier has two motions; the first drives it across the shed; the second pushes it further inward. During the first motion the grippers of the carrier are closed; during the second they are open. When home, the grippers are again closed, and they hold a thread.

Weft Feed. Weft bobbins stand at the sides of the loom, and from the bobbins the weft is led up through a guide eye into a tube with clearing and regulating appliances. Thence the thread passes into a measuring and tension apparatus, which pays out to the carrier exactly

the length of thread required, and then the shears come up and nip off the thread. The carrier bears the weft through the shed, and the slay comes up and drives it home. At the other side of the loom, the other end of the carrier performs in the same style. So thread by thread the loom works without stop. In other respects the Seaton loom is controlled by the same mechanism as the common power-loom. Should the weft fail from any cause, the weft fork will act and stop the loom.

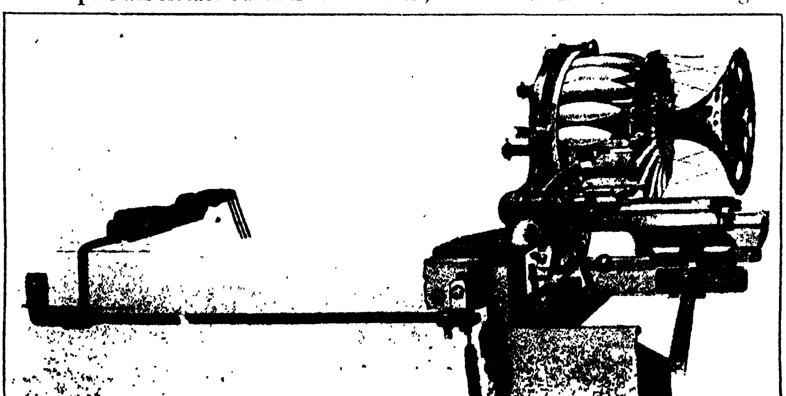
Automatic Weaving. The three looms so briefly sketched are taken as representative of the types of machine at present practical and in actual work. There are many others, for the difficulty of the problems involved attracts ingenious minds, and the profit offered for success is very great. Though thousands of Northrop looms are working on both sides of the Atlantic, and producing cloth constantly, it can hardly be accepted as the complete solution of the problems involved in automatic weaving. Production of plain cloth is only the first step in weaving. We do not belittle the Northrop in saying that it is a complex machine; it is the common power loom, with the automatic appliances added on. Add further the complexity of the dobby, the jacquard, the swivel, or the lappet, and we have complication of a bewildering kind. Looms of the Northrop and "Burnley" have undoubtedly a useful future before them, but the great difficulty in the way of complete automatism in the loom has not been overcome.

Some hint of the possible solution of the problem may be got from the "Seaton" loom, which discards the shuttle; but it seems that the whole method of forming fabrics should be thoroughly reconsidered. The lace loom, the various knitting machines, the gauze looms, the looms with changing warps and circular shuttle-boxes, all suggest that some machine lies hidden which, if discovered, would unify the whole of fabric manufacture. Unknown to all save their own workers, and, perhaps, a privileged observer, some manufacturers have already made considerable strides towards the realisation of this ideal. At the present moment there are horizontal looms upon which lace curtains are woven; cloth



168. WEFT-FEED MOTION ON NORTHROP LOOM

is being made on what has hitherto been deemed only a knitting machine; the traditional alternation of warp and weft has been obviated in the secret production of several kinds of fancy fabric. These mysteries lie far beyond the limits of our present study; but we point to the facts as showing how progress is being made, though no trumpeting proclaims it, and as a stimulus to further effort. Weaving is a practical business, and the wise manufacturer is more concerned about making a profit than achieving fame as an inventor. He devises methods of making a fabric for which he hopes to have a sale; the market supplied, he discards the mechanism for something else. The field of manufacture is strewn with discarded contrivances, many of them valuable if we could recover them. The art of weaving has progressed, but much remains to be done.



169. WEFT FORK OF NORTHROP LOOM, SHOWING CONNECTION WITH CARRIER

Continued

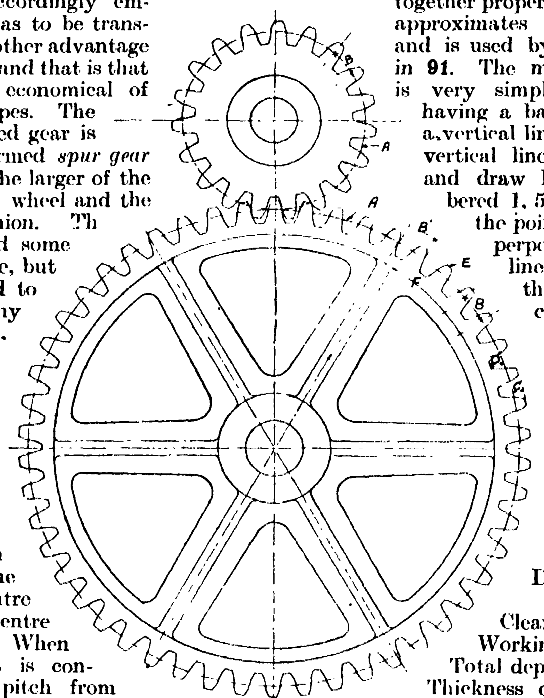
SPUR WHEEL TEETH

Toothed Gears. Pitch Circles. Proportions of Teeth. Scale for Teeth. Forms of Teeth—Cycloidal and Involute. How to Make and Use an Odontograph

By JOSEPH W. HORNER

Toothed Gears. We have seen that a belt or a rope does not transmit power accurately, but that a certain loss of speed occurs, due to "slip." Toothed gears are not open to this objection, and are accordingly employed where motion has to be transmitted accurately. Another advantage accrues from their use, and that is that they are much more economical of space than belts or ropes. The simplest form of toothed gear is shown in **86**, and is termed *spur gear* or *spur and pinion.* The larger of the two wheels is the spur wheel and the smaller one is the pinion. The term *pinion* is applied somewhat loosely in practice, but is generally understood to mean the smaller of any two wheels in contact, or any wheel having less than 20 teeth.

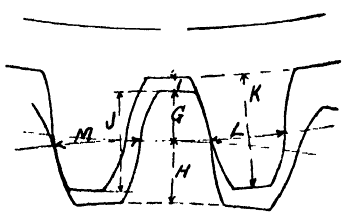
The dotted circles marked A are the *pitch lines* or *pitch circles;* these are the theoretical lines of contact and from them measurements are taken. The pitch of the teeth, B, is the distance from the centre of one tooth to the centre of the next one. When measuring a wheel it is convenient to take the pitch from the edges of the teeth, as B[1]. That portion of the tooth, C, which extends above the pitch line is termed the *face* or *addendum;* while that portion, D, which lies below the pitch line is called the *flank* or *dedendum.* The extreme outer end, E, of the tooth is the *point*, and the lower end, F, is the *root.*



86. SPUR WHEEL AND PINION

Proportions of Teeth. The average English proportions of gear teeth are indicated in **87**, and are as follows:

		pitch
Height of tooth above pitch line (G)	=	·33
Depth of tooth below pitch line (H).. ..	=	·40
Clearance at root (I) ..	=	·07
Working depth of tooth (J)	=	·66
Total depth of tooth (K)	=	·73 pitch
Thickness of tooth at pitch line (L)	=	·47
Space between teeth at pitch line (M)	=	·53



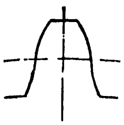
87. PROPORTIONS OF TEETH

It is very essential that a manufacturing house should have all its gear patterns made to some uniform system of proportion, so that any two wheels the same pitch shall work together properly. A useful *scale* which approximates the above proportions and is used by some firms is shown in **91**. The method of construction is very simple. Draw a triangle having a base line 12 in. long and a vertical line 4 in. long, divide the vertical line into 15 equal parts, and draw lines from parts numbered 1, 5, 6, 7, 8, 10, and 11 to the point of the angle. Erect perpendiculars on the base line in such positions that their respective lengths correspond with definite pitches, as $\frac{1}{4}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in., etc.; then on any vertical line the tooth dimensions for the corresponding pitch may be taken off with compasses, the proportions being:

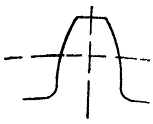
	pitch
Height of tooth above pitch line	$\frac{5}{15}$
Depth of tooth below pitch line ..	$\frac{6}{15}$
Clearance at root ..	$\frac{1}{15}$
Working depth of tooth..	$\frac{[illegible]}{15}$
Total depth of tooth ..	$\frac{11}{15}$
Thickness of tooth at pitch line	
Space between the teeth at pitch line	$\frac{8}{15}$

This scale is perhaps more useful in the pattern shop than in the office, as all the teeth are there marked out full size, and the dimensions can be taken off the scale direct and transferred to the pattern or tooth-block.

Forms of Teeth. The forms of the teeth of gear-wheels have occupied the attention of engineers to a very considerable extent; an ideal gear would have a constant motion identical with that of two smooth-faced pulleys whose diameter would represent the pitch circles in contact. If the tooth form does not permit this constant velocity at the pitch line, then a more or less noisy and inefficient gear results. A badly-formed tooth



88. DOUBLE CURVE TOOTH

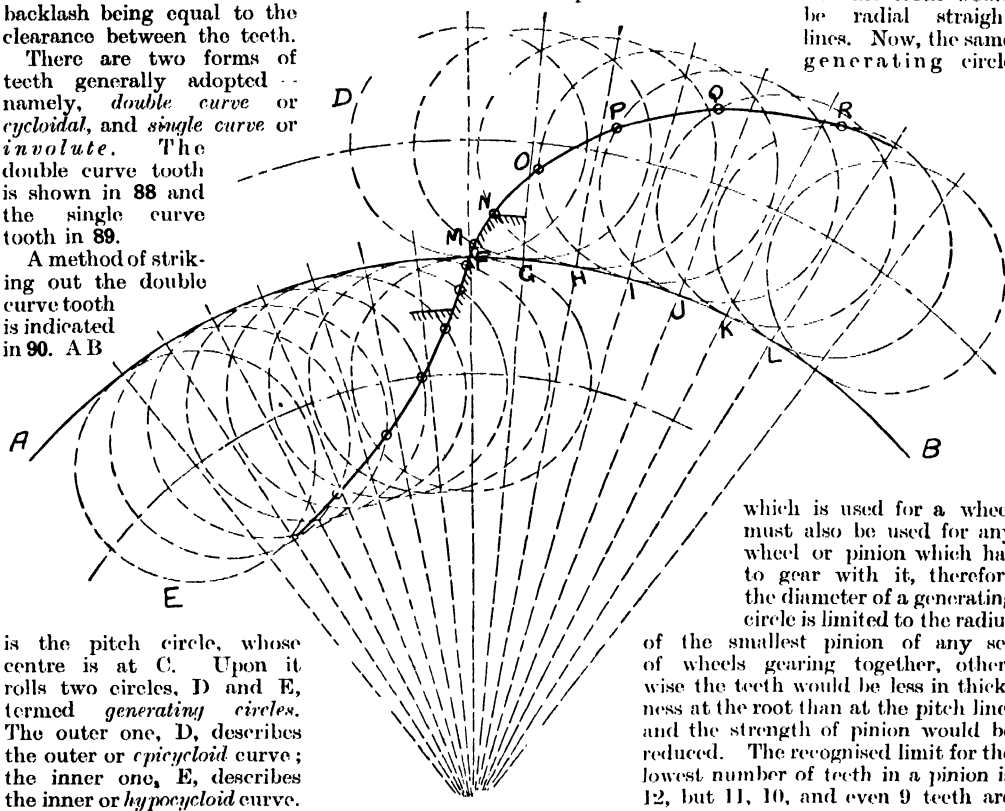


89. SINGLE CURVE TOOTH

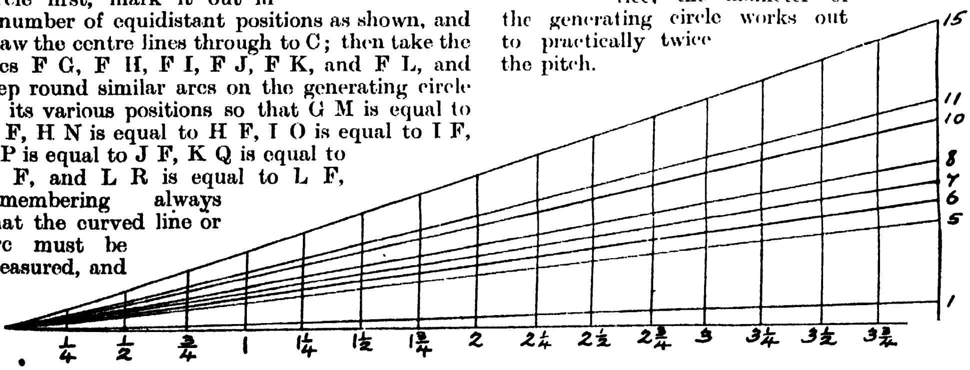
is contributory to what is called *backlash*. A variation in velocity causes relative movement between the teeth in gear, and they leave their driving faces and come into collision with the teeth in front of them, the amount of the backlash being equal to the clearance between the teeth.

There are two forms of teeth generally adopted—namely, *double curve* or *cycloidal*, and *single curve* or *involute*. The double curve tooth is shown in **88** and the single curve tooth in **89**.

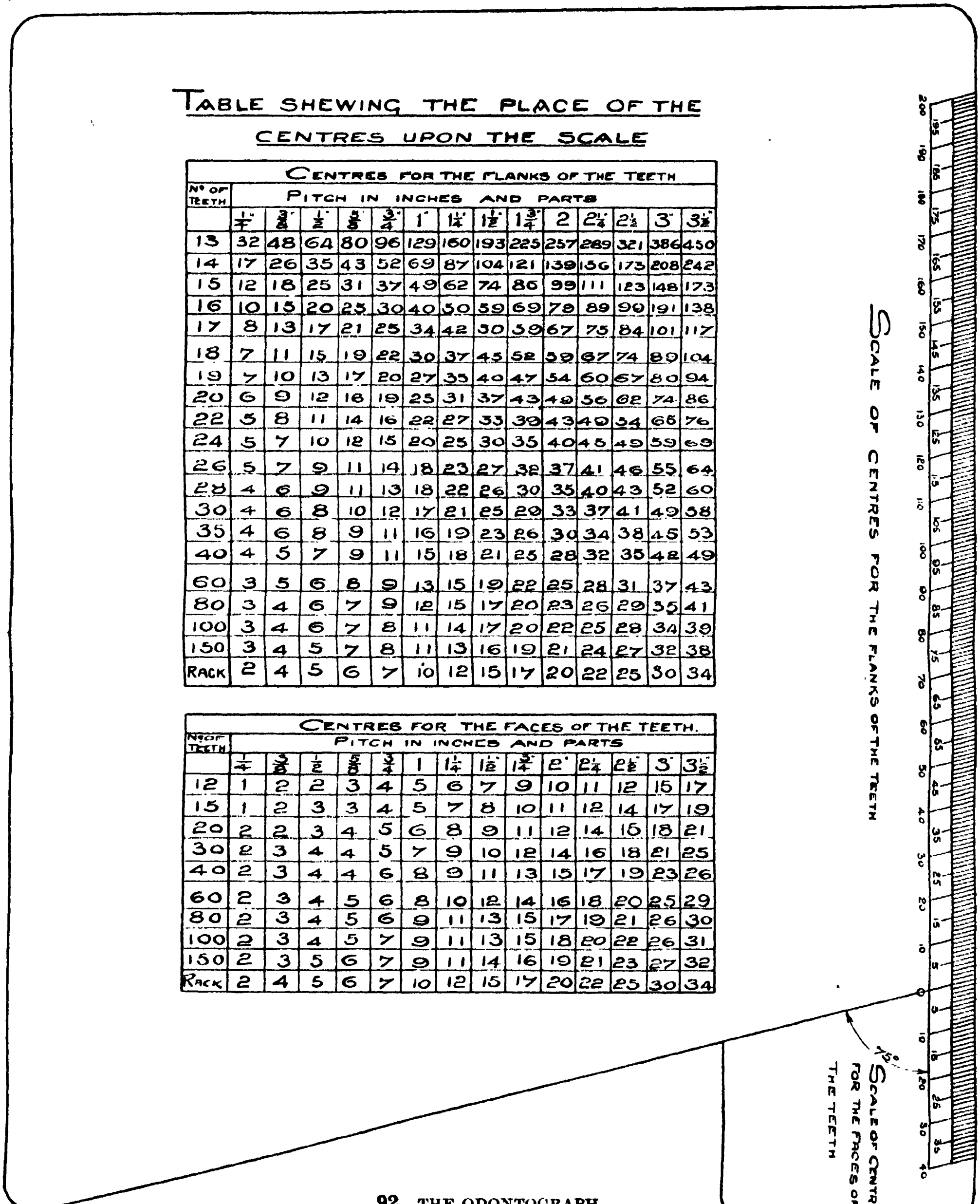
A method of striking out the double curve tooth is indicated in **90**. A B is the pitch circle, whose centre is at C. Upon it rolls two circles, D and E, termed *generating circles*. The outer one, D, describes the outer or *epicycloid* curve; the inner one, E, describes the inner or *hypocycloid* curve. The diameter of each circle may be taken at twice the pitch. Taking the outer circle first, mark it out in a number of equidistant positions as shown, and draw the centre lines through to C; then take the arcs F G, F H, F I, F J, F K, and F L, and step round similar arcs on the generating circle in its various positions so that G M is equal to G F, H N is equal to H F, I O is equal to I F, J P is equal to J F, K Q is equal to K F, and L R is equal to L F, remembering always that the curved line or arc must be measured, and not a straight line or chord. Through the points M, N, O, P, Q, and R lies the true path of the *epicycloid* curve. The *hypocycloid* is obtained in a similar manner, with the inner generating circle rolling in the reverse direction. Only a portion of the curve is required for a tooth, as shown in hatched lines. The diameter of the generating circle has a great influence on the thickness of the tooth at the root and at the point; if it were made of equal diameter to the radius of the pitch circle the flanks of the teeth would be radial straight lines. Now, the same generating circle which is used for a wheel must also be used for any wheel or pinion which has to gear with it, therefore the diameter of a generating circle is limited to the radius of the smallest pinion of any set of wheels gearing together, otherwise the teeth would be less in thickness at the root than at the pitch line, and the strength of pinion would be reduced. The recognised limit for the lowest number of teeth in a pinion is 12, but 11, 10, and even 9 teeth are not uncommon on cranes and winches. Taking, however, 12 teeth as the minimum in average practice, the diameter of the generating circle works out to practically twice the pitch.



90. CYCLOIDAL CURVE



91. SCALE FOR PROPORTIONS OF TEETH



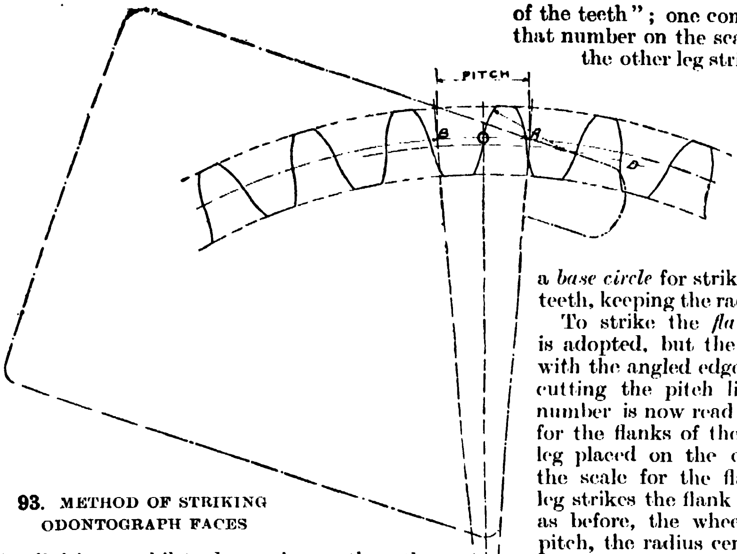
Nº of Teeth	Centres for the flanks of the teeth — Pitch in inches and parts													
	1/4"	3/8"	1/2"	5/8"	3/4"	1"	1¼"	1½"	1¾"	2	2¼"	2½	3"	3½"
13	32	48	64	80	96	129	160	193	225	257	289	321	386	450
14	17	26	35	43	52	69	87	104	121	139	156	173	208	242
15	12	18	25	31	37	49	62	74	86	99	111	123	148	173
16	10	15	20	25	30	40	50	59	69	79	89	99	191	138
17	8	13	17	21	25	34	42	50	59	67	75	84	101	117
18	7	11	15	19	22	30	37	45	52	59	67	74	89	104
19	7	10	13	17	20	27	35	40	47	54	60	67	80	94
20	6	9	12	16	19	25	31	37	43	49	56	62	74	86
22	5	8	11	14	16	22	27	33	39	43	49	54	65	76
24	5	7	10	12	15	20	25	30	35	40	45	49	59	69
26	5	7	9	11	14	18	23	27	32	37	41	46	55	64
28	4	6	9	11	13	18	22	26	30	35	40	43	52	60
30	4	6	8	10	12	17	21	25	29	33	37	41	49	58
35	4	6	8	9	11	16	19	23	26	30	34	38	45	53
40	4	5	7	9	11	15	18	21	25	28	32	35	42	49
60	3	5	6	8	9	13	15	19	22	25	28	31	37	43
80	3	4	6	7	9	12	15	17	20	23	26	29	35	41
100	3	4	6	7	8	11	14	17	20	22	25	28	34	39
150	3	4	5	7	8	11	13	16	19	21	24	27	32	38
Rack	2	4	5	6	7	10	12	15	17	20	22	25	30	34

Nº of Teeth	Centres for the faces of the teeth. — Pitch in inches and parts													
	1/4	3/8	1/2	5/8	3/4	1	1¼	1½	1¾	2"	2¼	2½"	3"	3½"
12	1	2	2	3	4	5	6	7	9	10	11	12	15	17
15	1	2	3	3	4	5	7	8	10	11	12	14	17	19
20	2	2	3	4	5	6	8	9	11	12	14	15	18	21
30	2	3	4	4	5	7	9	10	12	14	16	18	21	25
40	2	3	4	4	6	8	9	11	13	15	17	19	23	26
60	2	3	4	5	6	8	10	12	14	16	18	20	25	29
80	2	3	4	5	6	9	11	13	15	17	19	21	26	30
100	2	3	4	5	7	9	11	13	15	18	20	22	26	31
150	2	3	5	6	7	9	11	14	16	19	21	23	27	32
Rack	2	4	5	6	7	10	12	15	17	20	22	25	30	34

92. THE ODONTOGRAPH

The Odontograph. The odontograph is an instrument invented to avoid the labour of marking out the cycloidal curves for each and every size of wheel and pinion that may be required. Suitable radii are given upon the instrument for the faces and flanks of teeth for all ordinary numbers. One of its edges is cut to an angle of 75°, which can be laid in certain definite positions relatively to the pitch and pitch line, and so used in order to obtain the centres of the radii.

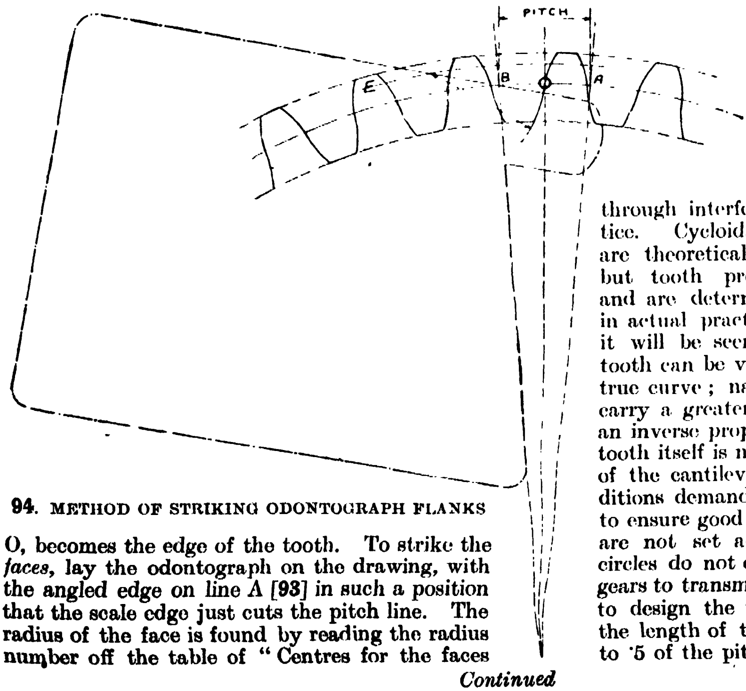
The odontograph is shown in **92**. It can be made by the student of stiff drawing paper or Bristol board. The width may be 10½ in. and the length 13¾ in. measured over the point. The angle of the sloping edge is 75°, and this angle is carried through as a line to the edge of the scale. Marking this line at zero, the scale is laid down parallel to it right and left in ½ in. divisions, each division being subdivided into 10 parts. The scale on the point comprises



93. METHOD OF STRIKING ODONTOGRAPH FACES

40 divisions, whilst the scale on the other side has 200 divisions; the former gives radii for *faces* of teeth and the latter gives radii for the *flanks.* It is very convenient to have the tables of centres on the instrument as shown [92].

How to Use the Odontograph. First of all draw the pitch circle of the wheel required, also lines representing the tops and roots of the teeth; then lay down the pitch and bisect it on the pitch line, obtaining points A and B [**93** and **94**]; the centre of the bisection,



94. METHOD OF STRIKING ODONTOGRAPH FLANKS

O, becomes the edge of the tooth. To strike the *faces,* lay the odontograph on the drawing, with the angled edge on line A [**93**] in such a position that the scale edge just cuts the pitch line. The radius of the face is found by reading the radius number off the table of "Centres for the faces of the teeth"; one compass leg is placed against that number on the scale of centres for the faces, the other leg strikes the face curve from O. Suppose the wheel to have 40 teeth $2\frac{1}{2}$ in. pitch, then according to the table the radius centre is at 19 on the scale. Having once found this centre, a dotted circle D may be drawn through it and used as a *base circle* for striking the faces of the other teeth, keeping the radius constant for each face.

To strike the *flanks* [**94**] a similar method is adopted, but the odontograph is now laid with the angled edge on B, the scale edge again cutting the pitch line. The required radius number is now read off the table of "Centres for the flanks of the teeth," and the compass leg placed on the corresponding number on the scale for the flanks; the other compass leg strikes the flank curve from O. Assuming, as before, the wheel to have 40 teeth $2\frac{1}{2}$ in. pitch, the radius centre is at 35, and a dotted circle E may be drawn through it as a *base circle* for striking the flanks of the other teeth.

The odontograph does not provide for pinions having less than 12 teeth, and such pinions must therefore be set out by means of generating circles, as previously described, the diameters of the circles being taken at half the diameter of the pinion.

The depth of wheel teeth is quite independent of the tooth curves, and it may be noted here that there is at present a distinct tendency to use shorter teeth than formerly; this tendency takes effect in machine-cut gear (described in the next lesson), and would undoubtedly obtain in ordinary cast gear but for the confusion that would arise in many engineers' shops through interference with existing practice. Cycloidal and involute curves are theoretical lines, and do not vary; but tooth proportions are arbitrary, and are determined by trial and error in actual practice. For instance, in **90** it will be seen that the length of the tooth can be varied without affecting its true curve; naturally a short tooth will carry a greater load than a long one in an inverse proportion to its length; the tooth itself is no stronger, but the length of the cantilever is less. Working conditions demand teeth of sufficient length to ensure good contact even when wheels are not set accurately and the pitch circles do not coincide. In dealing with gears to transmit great power, it is usual to design the teeth specially, and then the length of the tooth may be reduced to ·5 of the pitch, or even less.

Continued

ITALIAN—FRENCH—GERMAN

Italian by F. de Feo; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

ITALIAN

Continued from page 3499

By Francesco de Feo

THE PRONOUN

Personal Pronouns

The personal pronouns are substantives of three persons.

The first person indicates the person who is speaking: *io cammino*, I walk.

The second person indicates the person to whom we speak: *tu leggi*, thou readest.

The third person indicates the person of whom we speak: *egli canta*, he sings.

First person singular *io* (subj.), I; *me* (complement), me (pronounced *ee-o*, *meh*).

First person plural *noi* (subj. and compl.), we, us.

Second person singular *tu* (subj.), thou; *te* (compl.), thee (pronounced *too*, *teh*).

Second person plural *voi* (subj. and compl.), you.

Third person singular, masculine, *egli*, *esso* (subj.), he, it; *lui*, *esso* (compl.), him, it.

Third person singular, feminine, *ella*, *essa* (subj.), she, it; *lei*, *essa* (compl.), her, it.

Third person plural, masculine, *essi* (subj.), they; *loro*, *essi* (compl.), them.

Third person plural, feminine, *esse* (subj.), they; *loro*, *esse* (compl.), them.

For both genders and numbers: *sè* (compl.), *oneself*, *himself*, *herself*, *etc.*

1. The forms *lui*, *lei*, *loro*, are commonly used as subjects instead of *egli*, *essa*, etc. This is the case (1) when attention is particularly called to the subject; (2) after *anche* (also), *più* (more), *nemmeno* (not even), and similar words. Examples: *Lo dice lui* (*ma non io*), He says so (but not I); *Anche lei era là*, She also was there.

2. The forms *me*, *te*, *lui*, etc., must always be used instead of the subjective forms when they stand as the second term of a comparison. Examples: *Egli studia più di te*, He studies more than thou; *Io sono meno ricco di lui*, I am less rich than he.

3. The pronoun of the third person *sè* is always referred to the subject of the sentence, as: *Pietro pensa per il suo amico Carlo, ma Carlo pensa solo per sè*, Peter thinks for his friend Charles, but Charles thinks only for himself. (Note that *per lui* in this sentence would mean *for Peter*.)

4. *Noi* and *voi* may be strengthened by the addition of *altri* (for the masculine), *altre* (for the feminine), as: *Noi altri andiamo a casa*, We are going home; and all the pronouns may be strengthened by placing after them *stesso*, *-a*, *-i*, *-e*, which correspond to the English *self*, *selves*. Example: *L'ho visto io stesso*, I have seen it myself; *Essa stessa venne da me*, She herself came to me; *Egli pensa solo a sè stesso*, He only thinks of himself.

5. Prepositions (*di*, *a*, *da*, *in*, *con*, *su*, *per*, *etc.*) are followed by the objective forms, as: *Io non ho paura di lui*, I have no fear of him; *Ho una lettera scritta da lei*, I have a letter written by her; *Venite con me*, Come with me; *Pietro è andato con lui*, Peter has gone with him.

6. Instead of *con me* (with me), *con te* (with thee), the contracted Latin forms *meco*, *teco*, may be used. Note that *seco* means *con lui* (with him), *con lei* (with her).

EXERCISE XXIII.

cascare (*cah-scàh-reh*), to fall
capire (*cah-peè-reh*) to understand
accompagnare (*ahccompah-neeàhreh*), to accompany
tenère (*tehnèh-reh*), to keep (to have)
pacco (*pàhcco*), parcel
proposta (*propòstah*), proposal
bisogno (*beesò-neeo*), need
invece (*eenvèh-cheh*), instead

Note the following expressions, in which the verb "to be" in Italian must agree with its subject: It is I, *sono io*; it is thou, *sei tu*; it is he, *è lui*; it is they, *sono essi*; it is not they, *non sono essi*; it was not we, *non eravamo noi*, etc.

1. Noi abbiamo lavorato più di voi. 2. La lèttera è stata scritta da me e non da lui. 3. Se voi accompagnate me, io accompagnerò voi. 4. Esse pènsano sempre tutto il contràrio di quello che dicono. 5. Loro crèdono di far bene, e invece fanno molto male. 6. Noi non abbiamo mai niente; essi tèngono tutto per loro. 7. Lei é gentilissima, ma lui no. 8. Quando siamo stati in bisogno, esse hanno sempre fatto molto per noi. 9. Tu pensi sempre a te, e non pensi mai agli altri. 10. Un signore ha domandato di voi.

EXERCISE XXIV.

1. Where are you going? If you will wait a little longer I will come with you. 2. You have come in time; we were just speaking of you. 3. We thought it was he, not she. 4. One should learn to do everything by oneself. 5. We have written to him as well as to her several times, but they never answered our letters. 6. Who has broken that vase? 7. Not I, it has fallen by itself. 8. To whom have you consigned the parcel—to him or to her? 9. To neither of the two, because they were not at home. 10. I cannot understand (*non posso* or *non so capire*) why he has made such a proposal to me.

Idioms

The four irregular verbs of the first conjugation (*stare, andare, dare, fare*) are used in many idiomatic expressions.

The most common of these expressions are:
star bene, star male, to be well, to be ill
star mèglio, star pèggio, to be better, to be worse
come state? how are you? how do you do?
state a sentire, listen
stare a disàgio, to be uneasy
stare in forse, to be in doubt
stare in pensiero, to be anxious
stare allegro, to be gay
star quieto, to keep quiet
andar via, to go away
andare a monte, to prove vain
andar tentoni, to grope about
andar d'accordo, to agree
va bene, good, all right
dare a intèndere, to make one believe
dare in prèstito, to lend
dar disturbo, to trouble
non fa niente, no matter
far tardi, to be late
che tempo fa? what kind of weather is it?
far mostra, to make a show
far calazione, to breakfast
far conto, to reckon
fatemi sapère, let me know
far attenzione, to pay attention
fare a meno, to do without
far fronte, to face
far orècchio del mercante, to pretend not to hear

CONVERSAZIONE

Che tempo fa?

Cattivo tempo.

Sarà mèglio aspettare ancòra un poco.

Aspettate voi; io vado a cercare una carrozza e ritorno sùbito.

Va bene; ma fate presto, se no faremo troppo tardi.

Avete fatto colazione?

Si; ho incontrato un mio amico, e ho fatto colazione con lui.

Come sta vostro padre?

Sta molto mèglio, grazie. E come stanno i bambini?

La bambina è sempre un po'pallidùccia; sto molto in pensiero per lei.

Che cosa farete domani? Andrete di nuovo da vostra cugina?

Si; andrò da lei. Poverina, non sta bene.

Quando fate conto di restare un po' con noi?

Spero di esser lìbero per la pròssima settimana, e allora profitterò della vostra gentilezza.

Con chi avete parlato, con lui o con lei?

Ho parlato con lei, ma questa sera o domani al più tardi andrò a parlare anche con lui.

Fate attenzione alle loro parole.

KEY TO EXERCISE XXI.

Andremo? Andiamo. Non andiamo. Non andremo. Andàrono. Andammo. Io diedi. Non darò. Lo (*it*) farete? Lo fo *or* fàccio *or* sto facendo. Lo fanno? Non daranno? Sta? Non starà. Andaste? *Sono* andato. Se dessi. Non darebbe? Essi non lo farèbbero. Non andrò? Non andaste. Sarèbbero andati. Se io non fossi andato.

NOTE. The compound tenses of the verb *andare* are formed with the auxiliary *èssere*. The past participle after *èssere* must always agree with the subject of the sentence.

KEY TO EXERCISE XXII.

1. Noi andiamo a teatro stasera. 2. Voi dove andate? 3. Che cosa faremo domani? 4. Io vado *or* andrò in campagna. 5. Noi andremo a vedere la chiesa nuova. 6. Che cosa fate? 7. Sto copiando un interessantìssimo passàggio da questo libro. 8. Date qualche cosa da mangiare a questo ragazzo; ha fame. 9. È necessàrio che io vada in città. 10. Facciamo presto, è molto tardi. 11. Io vado un pochino fuori e ritornerò a ora di pranzo.

Continued

FRENCH

Continued from page 3501

By Louis A. Barbé, B.A.

VERBS—continued

Peculiarities of the First Conjugation. 1. Verbs ending in CER, such as *avancer*, to advance; *prononcer*, to pronounce, take a cedilla under the c before *a* and *o*, as an indication that the soft sound of the *c* is to be retained: *nous prononçâmes, nous avançons.*

2. Verbs ending in GER, such as *manger*, to eat; *partager*, to share, retain *e* after *g* before *a* and *o*, so that the *g* may have the same soft sound as in the infinitive: *nous mangeons, partageant.*

The tenses and persons affected by these two rules are shown in the following table:

INDICATIVE

Present

nous avançons
nous mangeons

Imperfect

j'avançais, tu avançais, il avançait, ils avançaient.

je mangeais, tu mangeais, il mangeait, ils mangeaient.

Past Definite

j'avançai, tu avanças, il avança, nous avançâmes, vous avançâtes.

je mangeai, tu mangeas, il mangea, nous mangeâmes, vous mangeâtes.

IMPERATIVE

avançons
mangeons

SUBJUNCTIVE

Imperfect

que j'avançasse, que tu avançasses, qu'il avançât, que nous avançassions, que vous avançassiez, qu'ils avançassent.

que je mangeasse, que tu mangeasses, qu'il mangeât, que nous mangeassions, que vous mangeassiez, qu'ils mangeassent.

PARTICIPLE PRESENT

avançant
mangeant

3. Verbs ending in ELER and ETER double the *l* and the *t* before a mute *e*, so that two mute syllables may not follow each other: *appeler*, to call; *j'appelle*, I call; *jeter*, to throw; *ils jettent*, they throw. The tenses and persons affected by this rule are shown in the following table:

INDICATIVE

Present

j'appelle, tu appelles, il appelle, ils appellent;
je jette, tu jettes, il jette, ils jettent

Future

j'appellerai, tu appelleras, il appellera, nous appellerons, vous appellerez, ils appelleront.
je jetterai, tu jetteras, il jettera, nous jetterons, vous jetterez, ils jetteront

CONDITIONAL

Present

j'appellerais, tu appellerais, il appellerait, nous appellerions, vous appelleriez, ils appelleraient.
je jetterais, tu jetterais, il jetterait, nous jetterions, vous jetteriez, ils jetteraient.

IMPERATIVE

appelle, qu'il appelle, qu'ils appellent;
jette, qu'il jette, qu'ils jettent.

SUBJUNCTIVE

Present

que j'appelle, que tu appelles, qu'il appelle, qu'ils appellent;
que je jette, que tu jettes, qu'il jette, qu'ils jettent.

It is to be noted that, although the infinitive has but one *l* or *t*, the future and the present conditional, which are formed from it, double the consonant throughout. The reason for this is that whilst in the infinitive the *r* goes with the *e* to form a sounded syllable: *ap-pe-ler, je-ter*, after the addition of *ai* or *ais*, etc., it is joined to these endings, and leaves the preceding *e* mute: *j'ap-pe-le-rai, je je-te-rais.* But this new division of the syllables gives two consecutive mute syllables. It is to avoid this that the consonant is doubled: *j'ap-pel-le-rai, je jet-te-rais*, etc.

4. A few verbs in ELER and ETER, instead of doubling the *l* and the *t* before mute *e*, take a grave accent on the *e* that precedes those consonants: *acheter*, to buy; *j'achète*, I buy; *geler*, to freeze; *il gèle*, it is freezing. Such are the following:

bourreler, to torment	*acheter*, to buy
celer, to conceal	*becqueter*, to peck
ciseler, to carve	*breveter*, to patent
geler, to freeze	*crocheter*, to pick (a lock)
démanteler, to dismantle	*décolleter*, to uncover the neck
denteler, to indent	*déchiqueter*, to cut up
écarteler, to quarter	*épousseter*, to dust
harceler, to harass	*étiqueter*, to label
peler, to peel	*haleter*, to pant

5. Verbs that have a mute *e* in the last syllable but one of the infinitive, take a grave accent on that *e* when it is followed by another mute syllable, as *mener*, to lead; *je mène*, I lead; *soulever*, to raise; *je soulèverai*, I shall raise.

The tenses and persons affected by this rule are the same as those that double the *l* and the *t* in verbs in *eler* and *eter*.

6. Verbs that have *é* in the last syllable but one of the infinitive, like *espérer*, to hope, *céder*, to yield, change the acute accent into a grave accent before a mute syllable.

This rule does not, however, affect the future or the conditional:

céder, je cède, ils cèdent, qu'il cède, but *je céderai, je céderais.*

7. Verbs ending in *yer* change *y* into *i* before a mute syllable: *ployer*, to bend, *je ploie*, I bend; *essuyer*, to wipe, *j'essuierai.*

The tenses and persons affected by this rule are the same as those that double the *l* and the *t* in verbs in *eler* and *eter*.

If the ending *yer* is preceded by *a*, as in *payer*, to pay, the *y* may be, and usually is, retained before a mute syllable: *payer, je paye, je payerai.*

8. It is to be noted that in the ordinary course of regular conjugation verbs in *ier*, like *prier*, to pray, take *ii* in the first and second persons of the imperfect indicative and of the present subjunctive: *nous priions, vous priiez, que nous priions, que vous priiez.*

9. It is also to be noted that verbs in *éer*, regularly take *ée* where other verbs have only one *e*, as *agréer*, to accept, *j'agrée*, I accept, *il agréera*, he will accept. In the masculine past participle they have *éé*, and in the feminine *éée*. Example: *créé, créée*: *L'âme a été créée immortelle*, The soul has been created immortal.

EXERCISE XXV.

1. The more he advanced in age, the more he advanced in wisdom (*la sagesse*).

2. The manner (*la manière*) in which (*dont*) the Romans pronounced Latin was very different from that in which we pronounce it nowadays (to-day).

3. He divided his fortune between (*entre*) his three children.

4. According to (*selon*) a French proverb (*le proverbe*), appetite comes from (*en*) eating.

5. He invokes (calls) upon his benefactor (*bienfaiteur*) the blessings (*bénédictions*) of heaven.

6. It is said of a man who squanders (*dissiper*) his fortune, that he throws his money out of (*par*) the window.

7. That letter brings us (*annoncer*) good news.

8. The lesson begins at page seventy.

9. Send that timepiece to the watchmaker's (*horloger*) in order that he may put it right (*arranger*).

10. I would willingly (*volontiers*) wager (*gager*) a hundred francs that it is not he who will carry off the prize.

11. In 1660, Charles II. was recalled (*rappeler*) to the throne (*le trône*).

12. That fish is too small; throw it back (*rejeter*) into the water.

13. When the fishermen are out at sea (*en pleine mer*) they will cast their net (*le filet*).
14. Those who employ (*employer*) their time badly are the first to complain (*se plaindre*) of its shortness (*brièveté*).
15. Light takes (employs) from seven to eight minutes to come to us from the sun.
16. We often pardon (*pardonner à*) those who bore (*ennuyer*) us; but we rarely pardon those whom we bore.
17. We have bought the victory at the price of our best soldiers.
18. What is bought retail (*en détail*) is dearer (*cher*) than what is bought wholesale (*en gros*).
19. It has frozen all night; if it still freezes to-morrow we shall perhaps be able (*pourrons*) to skate (*patiner*) Saturday.
20. God drew (*tirer*) heaven and earth from nothingness (*le néant*); He created them by His word (*la parole*).
21. Accept (*agréer*), sir, my respectful salutations—(a) formula (*la formule*) which is often used in ending a letter.
22. We are sometimes obliged to yield (*céder*) to circumstances (*circonstance*).
23. It is not he who possesses his fortune, it is his fortune that possesses him.
24. Every road leads to Rome, says the proverb.

Continued

GERMAN

Continued from page 3504

By P. G. Konody and Dr. Osten

LXXI. Verbs with Two Objects. With transitive and reflective verbs [see XLI., page 2489] the object (answering the question wen? whom? or was? what?) stands in the accusative (nearer object). If a second object, that of the person (answering to the question wem? whom? or was?) is in the sentence, it stands in the dative (more distant object). In sentences with two objects the dative object precedes the accusative, unless the latter is a personal pronoun: Er gab dem Bettler (dative object) ein Almosen (accusative object), he gave the beggar [an] alms; but: er gab es (accusative object, personal pronoun) dem Bettler (dative object), or: er gab es ihm.

It should be remembered that the reflective pronoun sich is the same in the dative and accusative. In sentences with two objects the distinction between the cases sounded alike can therefore only be made by putting the question Wem? to whom?—corresponding with the dative of the person: Der Radfahrer hat sich verletzt, the cyclist has hurt himself (whom? accusative object); and: Der Radfahrer hat sich (dative object) das Bein (accusative object) verletzt, the cyclist has hurt his leg (literally: The cyclist has hurt himself the leg). In the latter sentence the dative sich answers to the question (literally translated): To whom has the cyclist hurt the leg?

The verb werfen, to throw, is used irregularly with dative and accusative objects: Er warf ihn (accusative) in den Sand, He threw him into the sand; and: Er warf ihm (dative) Sand (accusative) ins Gesicht, literally: He threw him sand in the face (He threw sand in his face); and: Er warf ihn (accusative) mit Sand ins Gesicht, He pelted him (accusative) with sand in the face. In similar manner are used; Einem (dative) or Einen (accusative) auf die Finger klopfen, to knock (tap) someone on the fingers, in accordance with the question wem (dative)? or wen (accusative)? whom? Einem (dative) or Einen (accusative) in die Wangen kneipen (or kneiffen), to pinch someone's cheeks [in the cheeks]; and the verbs schneiden, to cut; stechen, to sting; beißen, to bite (to itch); treten, to step (to tread on).

LXXII. Intransitive Verbs Governing the Dative. Many intransitive and compound verbs require the complement of a noun standing in the dative, or govern the dative, such as Ich antworte Ihnen (dative), I answer you; Er ähnelt seinem Vater (dative), He resembles his father; Man muß der Not gehorchen, One must obey necessity; Er folgte der Fährte, He followed the track; etc. Where these nouns are of the personal kind (personal substantives or personal pronouns), this dative is a "dative of the person," in all other cases a "dative of the thing." Similarly the dative is required by several reflective verbs (reflecting an action on the acting person): er hilft sich (reflective pronoun dative), he helps himself. The following list of verbs requiring a complement in the dative should be carefully committed to memory:

Many compounds with the prepositions ab-, an-, auf-, aus-, bei-, ein-, ent-, er-, miß-, nach-, vor-, zu-; for instance: ab'helfen, to remedy; ab'raten, to dissuade from; an'gehören, to belong to; an'stehen, to beseem, to suit; auf'fallen, to be striking, to attract attention; auf'passen, to wait for, to watch, to spy; aus'helfen, to render temporary assistance; aus'weichen, to evade; bei'stehen, to help, relieve; bei'stimmen, to agree with, to assent to; ein'fallen, to fall in, to come into the mind; ein'stehen, to answer for; entflie'hen, to escape, to run away; entsprin'gen, to escape, to spring, to arise; erschei'nen, to appear, to be evident; erlie'gen, to succumb, to yield; mißfal'len, to displease; mißglü'cken, to fail; nach'forschen, to search, to inquire after; nach'stellen, to place behind, to pursue; vor'beugen, to bend forward, to prevent; vor'kommen, to overtake, to occur; zu'fallen, to shut (of itself); zu'sehen, to look at, to connive at; and many other verbs, such as ähneln, to resemble; ant'worten, to answer; bleiben, to remain; danken, to thank; dienen, to serve; drohen, to threaten; glücken (Einem), to succeed; schaden (Einem), to hurt, to damage, to spoil; zürnen, to be angry; lauschen, to listen, etc.

LXXIII. Impersonal Verbs. There are two kinds of impersonal verbs, the real and the seeming—the former connected with the neuter personal pronoun es, it, as their real and sole subject, whilst with the latter es precedes only the real subject. For instance in Es schwindelt mir, I am dizzy [in the sense it (an unknown

power) is dizzy within me], the verb ſchwindeln is a real impersonal verb; but in the sentence Es ſchwindelt mir **der Kopf**, My head is dizzy, the pronoun es precedes the subject „der Kopf", and the verb is only seemingly impersonal. Many real and seemingly impersonal verbs govern the dative of the person. With some „es" can be omitted: Wie iſt (es) Ihnen? How are you? [how is it with you?], but Wie **geht** es Ihnen? How are you? [how is it going with you?], where the es cannot be dropped.

1. In their impersonal form the verbs ſchwindeln, to be dizzy, giddy; ahnen, to forebode; ſcheinen, to shine, to appear, to seem, govern the dative of the person. Dünken, to seem, to appear, governs the dative or the accusative: Es dünkt (däucht) **mir** or **mich**, Methinks, it seems to me. The transitives freuen, to rejoice; ergötzen, to delight in; betrüben, bekümmern, to trouble, to grieve; verletzen, to hurt, to wound; ſchmerzen, to ache, to suffer pain, etc. govern the accusative with es, if there is no other subject: Es freut mich, I am glad [it gladdens me]; Es ſchmerzt mich, It hurts me, it grieves me, etc.

Some of these verbs have no passive form; it is impossible to use freuen, to rejoice, in the passive voice and to say: Ich bin gefreut, etc. The passive voice is in these cases formed by the help of compounds with the inseparable prefixes er-, be-, etc.: Ich bin **er**freut, ich war erfreut, etc.; ich bin **be**kümmert, I am grieved, etc. The following verbs are used with the dative of the person: fehlen, to miss; mangeln, to want, to lack; genügen, to suffice; gefallen, to please; behagen, to suit, to please; träumen, to dream, to imagine; mißraten, to fail, to miscarry; fehlſchlagen, to fail; klarwerden, to become clear about something, to dawn upon one; ein'leuchten, to be evident, obvious; frei'ſtehen, to be at the disposal, to be at liberty to; geziemen, to become, to beseem; vor'kommen, to happen, to occur.

2. With transitive impersonal verbs the genitive is sometimes used in the place of the subject in the nominative: Mich jammert dieſer Menſch, I feel pity for this man (literally: this man grieves me), or: Mich jammert **dieſes Menſchen** (genitive); Es lohnt **der Mühe** (genitive), it is worth while [of the while].

LXXIV. Verbs Governing the Genitive Case. The genitive is also used in certain cases with the auxiliary verbs ſein and werden: Er iſt des Todes (genitive), He is as good as dead [he is of death]; Es iſt nicht meines Amtes, It is not my business (my duty, my office). These and similar genitives are the result of omission: Er iſt (ein Kind) des Todes; es iſt nicht (die Sache) meines Amtes. Similarly genitives, that are not really dependent, but more of a predicative character, are employed in: Jemand iſt ſchlechter Art, freundlichen Weſens, anderer and gleicher Meinung, entge'gengeſetzter Anſchauung, ſchlechter Laune, etc.; literally: Someone is of bad kind (has a bad disposition), of friendly temper, of another *or* of the same opinion, of opposite view, of bad humour, etc. Genuine dependent genitives are used with the intransitive verbs bedürfen, brauchen, to want; denken, to think; gedenken, to remember; gewahren, to be aware; harren, to wait; ſpotten, to chaff, etc.

LXXV. The Expectation in Questions. It has been shown that the question, in German as in English, is formed by the simple displacement of subject and predicative verb. But in German the question may convey the expectation of the enquiring person as regards the affirmative or negative nature of the answer. Where the affirmation is expected or desired, the opposite negative **nicht**, not, is added: Kommt er nicht? Doesn't he come? This affirmative expectation can also be expressed by the addition of the conjunction doch, yet, however, and the adverb wohl, well, probably: er kommt doch? er kommt wohl? and er kommt doch wohl? If the affirmative is not desired, the adverb etwa, possibly, is added: kommt er etwa? Similarly Kommt er ſchon? Does he come already? conveys the hope that the person referred to is not coming yet.

LXXVI. Position of Words in a Simple Sentence. For normal positions see LXX., page 3503. If the predicate is a verb with a separable prefix, the latter stands at the end of the sentence in the simple tenses: an'hören, to listen to; Der Schüler hört den Lehrer an, The pupil listens to the teacher; and in the perfect: Der Schüler hat den Lehrer angehört, The pupil has listened to the teacher; aus'gehen, to go out; Ich ging nach dem Eſſen aus, I went out after the meal (after dinner); and: ich bin nach dem Eſſen ausgegangen.

1. Agreement of Subject and Predicate. The verb (predicate) agrees with the subject in person and number: der Vater ſchläft (singular), The father sleeps; and: die Kinder ſchlafen (plural), The children sleep, etc. With collective substantives the verb stands in the singular, but if the collective noun is directly connected with a substantive in the plural, the verb is employed in the plural: Das Gebirge erhob ſich vor meinen Augen, The mountain rose before my eyes; but: Ein Dutzend Fäſſer wurden (plural) gebracht, A dozen barrels were brought; Eine Menge Soldaten erſchienen (plural), A crowd of soldiers appeared.

2. A sentence with several subjects and one predicate, or with several predicates, attributes, objects, or adverbial nouns, and one subject, can be contracted to give the speech more conciseness and better rhythm. The part of the sentence to which the other words refer is not repeated: Das Sonnenlicht ſtimmt die Seele heiter, der Regen (ſtimmt die Seele) mißmutig, [The] sunlight makes the soul serene, [the] rain dreary.

(*a*) If a contracted sentence contains as subjects a personal pronoun in the first, and another in the second or third person, the predicate stands in the first person plural: Ich und du (or dein Bruder) zanken immer, I and you (*or* your brother) are always quarrelling; Ich und er ſind die beſten Freunde, I and he are the best of friends. With personal pronouns in the second and third person, the verb stands in the second person plural: Du und er (or deine Freunde) ſeid ſtets willkommen, You and he (*or* your friends) are always welcome.

(*b*) If the predicate refers to several subjects, it stands in the plural: Geld und gute Worte wirken Wunder, Money and good words work miracles.

(*c*) If several subjects are regarded as part of the same idea, the verb stands in the singular: Auf blutige Schlachten folgt (singular) Gesang und Tanz, Song and dance follow (plural) bloody battles.

3. If the common member of the sentence does not agree in gender, number, case, or tense with the other parts to which it belongs, no contraction can be effected. Thus: Ich begegnete und grüßte den Lehrer, I met and greeted the teacher, is wrong, because begegnen governs the dative, and grüßen the accusative. The correct form would be: Ich begegnete dem Lehrer (dative) und grüßte ihn (accusative), I met the teacher and greeted him, which is also a contraction, as the subject ich is mutual to both predicates, with which it agrees in person and number.

4. In sentences with several objects (*a*) the personal object precedes the other, the dative stands before the accusative, and the accusative before the genitive: Er sagte mir (3) die Wahrheit (4), He told me the truth; Die Gnade des Königs rettete ihm (3) das Leben (4), The king's mercy saved his life [saved him the life]; Man darf ein Tier (4) nicht mutwillig des Lebens (2) berauben, One must not take wantonly an animal's life; Der Richter beschuldigte den Gefangenen (4) des Verbrechens (2), The judge accused the prisoner of the crime.

(*b*) The prepositional object is placed after the simple object in the accusative: Der Sohn frug seinen Vater (4) um (preposition governing the accusative) Erlaubniß, The son asked his father for permission.

5. The adverb precedes the word which it qualifies: Ich beabsichtigte heute (adverb of time) abzureisen, I intended to depart to-day. Where there is an object of the person and another object, the adverbs are generally placed between them: Sie werden mir (personal object) morgen (adverb of time) alles (object) erzählen, You will tell me all to-morrow. Where there are several adverbs it should be remembered that the adverb of time usually precedes those of place, manner and cause: Er mußte gestern (time) plötzlich (manner) abreisen, He had to depart yesterday suddenly; Ich war heute (time) daheim (place) unausgesetzt (manner) tätig, I was to-day at home continually busy.

6. The negation nicht is placed after the verb (but before the past participle or infinitive in compound tenses), if it refers to the whole sentence. In all other cases it precedes that part of the sentence which has to be denied: Der Kaufmann hat nicht einen Brief geschrieben, sondern eine Rechnung, The merchant has not written a letter, but an invoice; Nicht der Kaufmann hat den Brief geschrieben, sondern der Geschäftsleiter, It is not the merchant who has written the letter, but the manager; Der Kaufmann hat den Brief nicht geschrieben (negation of the whole fact), sondern diktiert, The merchant has not written but dictated the letter.

7. The reflective pronoun precedes all other objects and adverbs and immediately follows the finite verb: Er ärgerte sich heute wieder über sein Mißgeschick, He was vexed again to-day about his misfortune.

8. Displacements of nouns (inversions) are far more frequent in German than in other languages, for reasons of euphony as well as for reasons of expressiveness and strength. In poetry, in particular, the word on which stress is to be laid is often placed at the beginning or the end of the sentence: Ernst ist das Leben, heiter ist die Kunst, Life is serious, art is gay; Sein ist alle Schuld! [his is all guilt], He alone is to blame!

EXAMINATION PAPER XIX

1. What is the relative position in the sentence, of the object of the person (dative), and the object in the accusative?
2. Which compound verbs and which simple verbs govern the dative?
3. How many kinds of impersonal verbs are there?
4. What rules determine the use of es with seemingly impersonal verbs?
5. How is the passive voice formed with such impersonal verbs as freuen, kümmern, etc.?
6. Which verbs are used with the dative of the person, and with which verbs can the subject in the nominative be replaced by a genitive?
7. With which auxiliary verbs is the genitive employed, and how can this genitive often be accounted for?
8. How can the question indicate the expectation of an affirmative or of a negative answer?
9. What is the normal position of the predicate in the simple sentence, and the relative position of the finite verb and the other part of the predicate in a compound tense?
10. If the subject of the sentence is a collective substantive, when is the predicate used in the singular, and when in the plural?
11. In which person is the finite verb employed in a contracted sentence containing personal pronouns in the first and second (or third) person as subjects? In the second and third person? When is it used in the singular? When is a contraction inadmissible?
12. What position is taken by the *personal* object in sentences with several objects, and what is the order of the objects, as determined by their cases (dative, accusative, genitive)? What is the position of the prepositional object, if the sentence also includes a simple accusative object?
13. What is the relative position of the adverb and the word qualified by it, and which adverbs precede, if the sentence contains more than one?
14. What considerations determine the position of the negative nicht in the sentence?
15. What is the position of the reflective pronoun?
16. What are the reasons for, and what is the effect of, the displacement of nouns?

CONVERSATIONAL EXERCISES

II. At the Hotel

Will you kindly pay the cabman?	Wollen Sie gefälligst den Kutscher bezahlen?
What is his fare?	Wie viel macht seine Taxe?
He drove me here from the station.	Er fuhr mich vom Bahnhofe hierher.
The fare, luggage included, is two marks 50 pfennigs.	Die Taxe einschließlich des Gepäcks beträgt 2 Mark 50.
Can you tell me how much that is in English money?	Können Sie mir sagen, wie viel das in englischem Gelde ist?
One mark is equal to one shilling, so the fare would be half a crown in English money.	Eine Mark ist gleich einem Schilling; die Taxe wäre demnach eine halbe Krone in englischem Gelde.
I want a room.	Ich benötige ein Zimmer.
On which floor?	In welchem Stockwerke?
On the first or second floor.	Im ersten oder zweiten Stockwerke; (also: in der ersten oder zweiten Etage).
This room is much too small, and, besides, the windows open on the yard.	Dieses Zimmer ist viel zu klein, und überdies gehen die Fenster auf den Hof hinaus.
Haven't you a bigger room with a view over the market place?	Haben Sie nicht ein größeres Zimmer mit der Aussicht auf den Marktplatz?
On the third floor there is a front room vacant.	Im dritten Stocke ist ein Frontzimmer frei.
Is it quiet?	Ist es ruhig?
The rooms looking on the garden are quieter.	Die Zimmer nach dem Garten sind ruhiger.
How much is this room?	Was kostet dieses Zimmer?
This room is five marks including attendance and electric light.	Dieses Zimmer kostet fünf Mark mit Bedienung und elektrischer Beleuchtung.
Will you bring my luggage?	Wollen Sie gütigst mein Gepäck bringen.
Please put the trunk by the door.	Den Koffer stellen Sie freundlichst zur Türe.
How about the meals? Is one compelled to take meals at the hotel?	Wie steht es mit den Malzeiten? Muß man die Malzeiten im Hotel nehmen?
Not in our hotel, but in other houses the visitor who takes his meals outside has to pay more for his room.	In unserem Hotel nicht, aber in anderen Häusern hat der Gast, der die Malzeiten auswärts nimmt, für das Zimmer mehr zu zahlen.
Where is the dining-room?	Wo ist der Speisesaal?
What can one have for breakfast?	Was kann man zum Frühstück haben?
Coffee, tea, chocolate, milk, bread, butter, eggs, ham.	Kaffee, Thee, Chocolade, Milch, Brot, Butter, Eier, Schinken.
Bring me some coffee and milk, bread, butter, two boiled eggs and some ham.	Bringen Sie mir eine Portion Kaffee mit Milch, Brot, Butter, zwei gekochte Eier und etwas Schinken.
The eggs are boiled too much, and the ham is too fat.	Die Eier sind zu hart gekocht und der Schinken ist zu fett.
Can't I have some lean ham?	Kann ich nicht mageren Schinken haben?
The table d'hôte begins at one p.m.	Die Table d'Hôte beginnt um ein Uhr mittags.
I prefer to take my meals à la carte.	Ich ziehe es vor, meine Malzeiten à la carte zu nehmen.
What soup is there to-day?	Was für Suppe gibt es heute?
We have pea soup and tomato soup.	Wir haben Erbsensuppe und Paradiesäpfel-Suppe.
Bring me some roast veal, potatoes, and French beans.	Bringen Sie mir einen Kalbsbraten mit Kartoffeln und grünen Bohnen.
What sweet will you take?	Welche süße Speise wünschen Sie zu nehmen?
Apple-tart.	Apfelkuchen.
The bill, please!	Ich möchte zahlen.
How much is it?	Wie viel macht es aus?
Bring me some warm water in the morning.	Bringen Sie mir des Morgens etwas warmes Wasser.
Give my washing to the laundress.	Geben Sie der Wäscherin meine Wäsche.
But I must have it back to-morrow evening.	Aber ich muß sie morgen Abend wiederbekommen.
I shall depart the day after to-morrow in the morning.	Ich reise übermorgen früh ab.
My luggage may be taken to the station.	Mein Gepäck kann zur Bahn gebracht werden.
If there are any letters for me, please forward them to Munich.	Wenn Briefe für mich kommen, so schicken Sie sie mir nach München nach.

Continued

THE HISTORY OF SUGAR

[See Food Supply, page 3692]

THE REFORMATION

The First of the Tudor Kings. Two Notorious Impostors. Henry VIII. and Cardinal Wolsey. The Days of the Renaissance. Martin Luther and the Reformation

By JUSTIN McCARTHY

HENRY VII., founder of the Tudor dynasty in England, married, soon after his accession, Elizabeth of York, the eldest daughter of Edward IV., as we have already seen. Henry had won his crown on the battlefield, but he was not a promoter of war, and had no inclination for the work of a soldier. He was a lover of peace, was much interested in the promotion of commerce and of international good understanding, and a patron of art and letters.

A Diplomatic Sovereign. He was one of the earliest of English kings who gave much time and attention to the development of diplomatic relations between England and other Continental states. Some of the marriages brought about during his reign bore striking testimony to his faculty for making international contracts, bearing promise of friendly relations with other states, which more enterprising and less scrupulous monarchs might have endeavoured to achieve by the sword.

Catherine of Aragon, daughter of Ferdinand and Isabella of Spain, was married to Henry's son, Arthur Prince of Wales, then only a boy, who died almost immediately after; and Henry, without delay, brought about the betrothal of Catherine to his next son, afterwards Henry VIII. with whom, on his succession to the throne, the marriage was solemnised. Henry also gave his eldest daughter, Margaret, in marriage to James IV. of Scotland; and thus the union of the two crowns, whose rivalry had been for so long a source of frequent war, was peacefully secured. Henry's preference for pacific arrangements was so marked that when, in 1492, in consequence of some serious quarrels, he invaded France, he made with Charles VIII. the Peace of Etaples, by means of which he obtained a large ransom and consented to withdraw his troops.

King or Scullion? Two notorious figures in Henry VII.'s reign were Lambert Simnel and Perkin Warbeck. Lambert Simnel accomplished a sort of far-distant anticipation of the Tichborne imposture of recent days. He was the son of a baker, and in 1487 represented himself as the Earl of Warwick, son of the Duke of Clarence who had been imprisoned in the Tower by Henry VII. on a political accusation for which he afterwards suffered death. Simnel passed himself off on many persons as the rightful heir to the Crown; and in Ireland his audacious venture met with so much success that he was crowned in Dublin as Edward VI., the rightful Sovereign of England. The feeling of the Dublin people probably was not friendly towards any existing English monarchy; and the fact of Lambert Simnel's not being recognised by the constitutional authorities in England was itself a strong recommendation. But Simnel carried his scheme too far when he crossed over to England and landed in Lancashire in June, 1487, with some 2,000 followers. He was defeated and taken prisoner at Stoke, but was treated by the King with singular clemency. He was not only allowed to live, but was even given an appointment as scullion and falconer to the Royal household. If Henry VII. possessed a sense of humour, it may well have seemed to him the most humiliating punishment he could inflict to convert this claimant to the Crown of England into a subservient and willing scullion.

Perkin Warbeck Imposture. Perkin Warbeck started a project much resembling that of Lambert Simnel. He was not an Englishman, and made his first appearance in public life in 1490 at the Court of the Duchess of Burgundy, sister of Edward IV. of England, and there claimed to be Richard Duke of York, the younger of the two sons of Edward IV., who were put to death in the Tower. He obtained a welcome reception at the Court of Charles VIII. of France; and in Scotland he was so well received that James IV. gave to him in marriage a kinswoman of his own, Lady Katherine Gordon. But when Perkin Warbeck tried more effective proceedings to obtain the Crown he was much less successful. He tried to organise an armed movement in England, but totally failed, surrendered on promise of pardon, and was put into prison. His uprising had not caused much disturbance, and it is possible that if he had remained in prison he might after a time have been released, as Henry VII. was not an unmerciful ruler. Warbeck, however, escaped from prison, was captured, and was then consigned to the Tower of London—a fact foreboding his impending doom. He was sentenced to death, and executed in November, 1499.

Henry died at Richmond on April 21st, 1509, and is said to have left behind him a vast treasure which he had gathered together by various devices, such as the imposition of large fines on offending barons or offending companies, and had hoarded with rigorous economy. It is stated that at the close of his reign it was found that he had bequeathed more than £2,000,000 to his successor.

The Early Days of Henry VIII. The successor to this treasure-holding ruler was his second son, Henry VIII., born 1491, who came to the throne under conditions at once auspicious and momentous. Few Sovereigns have ever been welcomed more cordially to the Royal position than was this boy king, who, during the first years of his reign, was regarded with hope, confidence, and affection by the great

majority of his subjects. Throughout his youth he was believed to be one of the handsomest, most accomplished, and most intellectual men of his time.

The Renaissance. But the reign of Henry did not justify these anticipations; and it has probably been the subject of more bitter criticism and more extreme differences of judgment than that of almost any other English Sovereign. Whole schools of conflicting historical studies have been founded on the discussion as to whether Henry's reign was, on the whole, a blessing or a curse to the people over whom he ruled and to a large portion of the world outside his own dominions. He came into power at a time when Europe was beginning to pass through that new Renaissance of literature and art, that sudden development of practical science, those new ideas of politics and religion, those new inventions for carrying on war which changed the conditions of the civilised world. New fields of colonisation were opening to Europe in Africa and in India; new forms of enterprise were discovered day after day in commerce and money-making; the traditions of the Middle Ages were fading away, and there was an eager demand for novelty in every domain of life.

Most important of all these changes was the appearance of new forms of religious faith. This change was making itself especially manifest in England, although it did not, at the outset, take anything like the definite form which it assumed at a later period of the reign.

Henry VIII.'s marriage proved to have a great influence on the political affairs of England so far as England's dealings with foreign states were concerned. A greater, indeed, almost an unbounded, influence over Henry during the earlier part of his reign was that of the famous Cardinal Wolsey. Wolsey, who was born in 1471, was the son of a wealthy butcher in Ipswich. At Magdalen College he obtained his degree so young that he was called the Boy Bachelor, and became master of a small school attached to his college. Through the influence of powerful friends he was appointed Chaplain to the Archbishop of Canterbury, and later became Chaplain to the King. After that his progress was rapid, and for a long time he held the King's favour. In 1514 he was appointed Archbishop of York, and in 1515 he was made Cardinal by Pope Leo X.

Battle of Flodden Field. At that time the Pope was still an important figure in the temporal as well as in the spiritual affairs of Europe, and was then engaged in forming the Holy League with Spain for the purpose of counteracting the growing power of France under Louis XII. Henry VIII. joined the Holy League against France, and in 1513 he conducted an invasion into France in co-operation with the German King Maximilian, where he won the bloodless Battle of the Spurs and captured several important positions. During Henry's absence from England a great victory was won for his crown over the Scots under James IV. James, who had taken the side of the French Sovereign against England, crossed with his army into Northumberland, where he encountered the Earl of Surrey at the memorable Battle of Flodden Field on September 19th, 1513. The victory was complete for the English with comparatively small loss, while James was killed on the battlefield with a large number of his most distinguished nobles, and, it is said, some 10,000 of his soldiers.

King and Cardinal. Wolsey took a very important part in the guidance of Henry's movements in all this warlike policy. The Sovereign and the Cardinal had the same purpose at heart—that of holding the balance between France and Spain, preventing the one from obtaining a mastery over the other, and thus making England, in a certain sense, the ruling power over both. Such a policy required a constant and almost unmeasured expenditure of money; and Cardinal Wolsey was the chief instrument in obtaining, by bold systems of taxation, the supplies needed by his Royal master.

Wolsey took upon himself openly and ostentatiously the responsibility for all this exaction; and it is only just to say that his object was, while directing the king's policy, to save his master from public censure, and to direct all the popular indignation towards himself. Later on, when it seemed important that England should draw closer towards a good understanding with France, Wolsey worked towards that end with as much statesmanlike ingenuity as he had formerly employed to bring about a quarrel with that country, and he came to hold, if possible, a higher position than before. In 1515 Wolsey was made Lord Chancellor of England.

Meeting on the Field of the Cloth of Gold. The continent of Europe was during this time kept in incessant suspense by the rivalry between Francis I. of France, and Charles V., Emperor of Germany. Charles inherited from his father the sovereignty of the Low Countries and of Burgundy, and the succession to the Imperial throne; and from his mother, daughter of Ferdinand and Isabella, he was entitled to the rulership of Spain, of Naples, and of the Spanish possessions in South America, where Spain had already secured a large territory. Francis maintained that Burgundy belonged to his dominions and not to any stranger, and he further claimed the Duchy of Milan and the territory of Flanders. Both monarchs wished for the support of England. Charles V. visited Canterbury to confer with Henry VIII., and Francis I. arranged the famous meeting on the plain of Ardres, known as the Field of the Cloth of Gold.

The frequent wars of those times left the ownership of this or that European territory a source of constant dispute. There was no distinct and recognised France or Germany, Italy or Spain as these are marked out and acknowledged in modern Europe. The Emperor of Germany was sometimes also the ruler of Spain, while the King of England claimed to be the lord of a large part of France. At length, one chapter of the struggle between Charles V. and Francis I. ended, for the time, in the complete defeat and capture of Francis at the Battle

of Pavia, in 1525. Then it became the policy of Henry VIII. and of Wolsey to take the opposite side. The power gained by the Emperor seemed to Henry to threaten the position of England as the power of France had appeared to threaten it before; and he and Wolsey believed it to be for the advantage of England to enter into an alliance with the King of France.

But, in the meantime, great movements were taking place throughout the Continent which had nothing to do directly with war or with political parties, but which brought about a revolution in human thought greater than any that had been wrought in the thoughts and the lives of men during all recent generations. It has been well said that every revolution, however great and powerful, is at first a thought in the mind of one man; and this may be said of the revolution then about to take place among the peoples of Europe.

Martin Luther. Luther, who was born at Eisleben, in Germany, on November 10th, 1483, belonged by birth to the working classes, and was the son of a German miner. Even in those days there was in Germany ample opportunity for youths of the poorer classes to obtain a good education; and Luther, after some study in the public schools, entered one of the universities and took his degree. He had from his earliest years a strong inclination for a spiritual life, had been a close student of the Scriptures, and spent three years in a monastic institution. He was ordained a priest in 1507, and won success as a preacher. Then he was sent to Rome, and with his stay there began that change in his religious views which led to such important events in the history of the world. His opposition to the doctrines of the Church of Rome began with his objection to the principle that the Pope and the Church had a spiritual right to grant what were called Indulgences to members of the Church. He returned to Germany, and there became, by his writing and preaching, an effective advocate of his own doctrines, and soon exercised a wide influence over the public opinion, not only of his own country, but of other European states as well. The longer the controversy went on the farther Luther found himself drawn away from his earlier faith; and before long he became an uncompromising opponent of the Church of Rome as the spiritual guide of Christianity.

"Defender of the Faith." There is no need to enter into the great religious controversy which divides the Christian world up to the present day. Its immediate effect upon the history of England is the most important subject of study in the story of Henry VIII.'s reign. Some of Luther's publications reached England, aroused much attention there, and had the immediate effect of provoking Henry VIII. into authorship and religious controversy. The King published a book as a reply to Luther's doctrine; and this reply found such a welcome in Rome that Pope Leo X. conferred upon the King the title of "Defender of the Faith," a title which was borne by Henry's successors long after the English crown had ceased to be worn by members of the Church of Rome. The King was understood to have been very proud of the success of his "Assertion of the Seven Sacraments."

Luther's publications met with much more success in Germany than in England, where, for the time, the leading force of influential public opinion seemed to go with the King. Luther's books were publicly burnt in St. Paul's by order of the Church authorities of England, and laws were put in force for the prosecution of any person who should take part in the promotion of the heretical doctrines. Luther's teaching was, however, spreading widely throughout Germany and over many parts of the Continent, and soon came to have a great effect on the minds of many of the thinkers and teachers of England. The whole religious controversy was much mixed up with the important political question as to the right of the Pope to any manner of control over the State affairs of countries outside his jurisdiction as a ruler. Henry VIII. came at last to identify himself thoroughly with the rejection of the Papal supremacy in religion, as well as in politics, and the bulk of English public opinion went with him. He suppressed most of the monasteries in England; and when uprisings took place in defence of them, he made that a reason for the suppression of all the other monasteries, and for the transference of their revenues to the Crown.

The Marriages of Henry VIII. The story of Henry's various marriages is not an edifying part of his reign. Henry insisted on obtaining a divorce from his wife, Catharine of Aragon, on the ground that the marriage was unnatural, as Catharine had actually been married to his elder brother just before his death. As the Pope was unwilling to assist the King to dissolve the marriage, Henry acted independently of the Papal authority, and married Anne Boleyn, a member of the ducal house of Norfolk. Henry appears to have fallen in love with Anne Boleyn, but his affection did not last long, for three years after the marriage he charged his wife with infidelity, and on that accusation she was put to death in 1536. The day before her execution, Henry married Jane Seymour, who died soon after, leaving a son, who became Henry's successor, Edward VI.

The King was quite ready for a new marriage, and chose Anne of Cleves as his fourth wife. This was not a marriage of affection, but one pressed upon Henry by some of those around him, on the ground that as she was a German and Lutheran princess his marriage with her might secure for England the support of the Protestant sovereigns and states of Germany. Henry accepted the union reluctantly, and within six months he obtained a legal decree declaring the marriage null and void. He then married Catharine Howard, another niece of the Duke of Norfolk; and before two years she underwent, too, the same accusation as that which had been brought against Anne Boleyn, and met with the like death penalty. The King then married his sixth wife, Catharine Parr, who outlived him.

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Continued from page 3598

SUGAR & THE SUGAR CANE

Properties and Uses of Saccharose, Lactose, Glucose, and Levulose. Propagation and Cultivation of the Sugar Cane. Its Yield and Composition

THE term *sugar* was formerly used to convey the idea of sweetness, and applied to products of both the vegetable and the mineral kingdoms. The term "sugar of lead" is a survival of this early usage. The word is now confined to those sweet substances which are found in the juices of plants. Chemically, sugar is classed with the carbohydrates, and the various kinds of sugar may thus be divided:

1. Saccharose, or cane sugar;
2. Lactose, or milk sugar;
3. Glucose, or grape sugar;
4. Levulose, or fruit sugar.

Saccharose. Saccharose, the most important sugar, is very widely distributed throughout the vegetable kingdom. The chief sources are the sugar cane, the sugar beet, palm, maple, sorghum, and maize. It is also found in noticeable quantities in carrots, madder-root, almonds, walnuts, barley, coffee beans, the sap of the lime, birch, and sycamore, mesquit pods, melons, and the nectar of flowers. It has been estimated that it would require the nectar of five and a half millions of red clover flowers to produce a kilogram of sugar; but, on the other hand, mesquit pods have been found to contain 29 per cent. of cane sugar.

Sources of Sugar. The coloured plate facing page 3649 represents the chief plants of the vegetable kingdom from which sugar is obtained on a commercial scale. Fig. A is a picture of the sugar cane, formerly the only source of sugar. It belongs to the grass order and is distinguished by its knotty stem. The whole plant is 8 ft. to 12 ft. in height. Figs. B, C, D, E show the chief varieties of the sugar cane and illustrate the characteristic features of the stems of (B) the Bourbon, (C) Black Tanna, (D) Striped Bamboo, and (E) Lahaina. The sugar beet shown in F, G, H, and J is the chief source of sugar in Europe. Fig. F shows the appearance of the beet when growing, G is an improved variety of beet, H is the white Silesian variety, while J shows the beetroot in section. Fig. K is sorghum, another source of sugar, L being the Early Amber cane, M a hybrid, and N the Liberian variety of sorghum. Fig. O is a scene in a forest of maple during the season of the collection of maple juice in Canada; this juice is afterwards boiled down to a thick syrup for household use, one of the methods being shown in P. Fig. Q is a familiar scene in India; it represents the manner in which the juice of the date palm is obtained. This juice when evaporated yields sugar of good flavour.

Properties of Saccharose. Cane sugar is a crystalline solid freely soluble in water, a cold, saturated solution containing over 65 per cent. of sugar, while as much as 82 per cent. of sugar can be taken up in a boiling solution. If a strong solution of sugar be slowly evaporated crystals are obtained which, if allowed to deposit on string, form *sugar candy*. Sugar is only slightly soluble in alcohol, and not at all in ether. When sugar is heated it melts, and if then allowed to stand till cold yields what is known as *barley sugar*. By combining butter and flavouring matter with melted sugar the familiar *butterscotch* is produced. If strongly heated, sugar darkens and gives a coloured product known as *burnt sugar*, or *caramel*. If the heat be continued and increased, acid vapours and combustible gases are given off and a black mass of charcoal remains behind. Sugar combines with lime to form a sucrate, the reaction forming the basis of an important method of purifying sugar juices. Strontia, baryta, and lead compounds can be formed in like manner.

The Difference between Cane and Beet Sugar. Cane sugar turns a ray of polarised light to the right, and has no reducing power on an alkaline sulphate of copper solution. These properties are made use of in sugar analysis, and are explained later. When sugar is warmed with sulphuric acid a black mass is obtained. Sugar mixed with chlorate of potash forms what is known as "white gunpowder," and takes fire if touched with sulphuric acid. When rubbed with lead oxide sugar takes fire. The question is often asked: What is the difference between beet and cane sugar? The answer is that sugars from any source are indistinguishable if equally purified. Impure beet sugar has a very disagreeable odour, but as such a product would not fetch a good price in the market it is obviously to the advantage of the manufacturer to thoroughly purify his beet sugar. An expert with a keen sense of smell could probably detect the difference between purified beet and cane sugar; but even experts make mistakes. The method is to put a few lumps of each in clean wide-mouthed stoppered bottles and let them remain for a day. On coming in from the fresh air and smelling each bottle it is sometimes possible to detect a difference. There is a slight difference in the amount of ash yielded by the two and also a chemical difference in the constituents. Beet sugar does not contain iron, as is sometimes erroneously stated.

Uses of Saccharose. Sugar is a cheap and economical food, although looked upon generally as merely a flavouring agent. It is an anti-putrescent, and on this account is used for preserving fruit. Sugar either *per sè* or as jam is recognised as a soldier's ration, and the cruder forms are much used as a valuable fodder for

cattle. Sugar is the source of alcohol in wines and beer, although cane sugar is not itself directly fermentable, but has to go through an intermediate stage before being acted upon by yeast.

Lactose, or Milk Sugar. This is the sugar found in the milk of mammals. Bouchardat states that it occurs also in the juice of the sapota tree, but this needs confirmation. Milk sugar is not so soluble in water as cane sugar, and its taste is much less sweet. When heated, milk sugar becomes yellow and then changes to brown; it reduces an alkaline sulphate of copper solution. When fermented with a yeast-like body milk sugar yields a drink called *koumiss.* Large quantities of lactose are used for infants' and invalids' food and also in the preparation of medicines.

Glucose. Glucose exists in grapes and honey. Small quantities exist in the animal body, the disease known as diabetes being characterised by an excessive secretion of glucose. On a manufacturing scale glucose is prepared by acting on starch with a dilute acid. Glucose dissolves in water, but is only about half as sweet as cane sugar. It is readily fermentable, and yields 48·67 per cent. of alcohol. Glucose is used in the brewing of beer, the manufacture of confectionery and jams, and in calico printing.

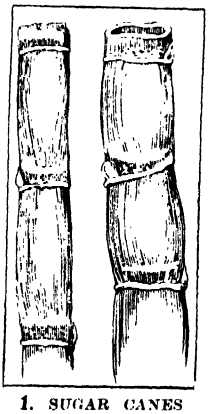
Levulose. Levulose exists in honey (with glucose) and ripe fruits. It is also contained to the extent of 50 per cent. in *invert* sugar—the product of the action of dilute acid on sugar. Levulose turns a ray of polarised light to the left. Invert sugar is of considerable importance in the brewing industry.

The Cane. The sugar cane is a huge grass with a knotty stem (1). It belongs to the natural order *Graminaceæ*, and is known botanically as *Saccharum officinarum.* The sugar cane is a native of India or of the most southern parts of Asia, whence it has spread to every tropical or semi-tropical country in the world. The Spaniards probably introduced the sugar cane into the West Indies and the American continent.

History of Sugar. Early writers, such as Herodotus, Theophrastus, and Seneca, were acquainted with sugar, but not till the Christian era do the references become clear. The cultivation of the sugar cane was well understood in Arabia and Spain from the earliest times, but the medicinal use of sugar was the object of the cultivation. During the Middle Ages England, in common with the rest of Northern Europe, was supplied with sugar from the Mediterranean, it being imported from Alexandria to Venice and thence to London. The average price of sugar in A.D. 1300 was 1s. per lb., and 100 years afterwards it was 1s. 7d. per lb. In 1353, John of France ordered that the apothecaries of Paris should not substitute honey for sugar in confections. As travelling became more general, the cultivation of the sugar cane spread, being introduced into Madeira in 1420, Domingo in 1494, the Canary Islands in 1503, Mexico in 1520, Martinique in 1650, Mauritius in 1750, and Australia in 1852. The cultivation of the sugar cane in Egypt almost became extinct, but of late years the Egyptian Government have made determined efforts to revive the manufacture of sugar. Factories on a scientific basis have been equipped, and the experiments have turned out successful. The discovery of beet sugar by Marggraf, of Berlin, in 1747, is referred to later on, the importance of the discovery being only apparent in recent years, when increasing cultivation of sugar beet has convulsed the cane sugar industry so much that international commercial agreements have had to be entered into to prevent the ruin of the sugar cane planters in the British possessions.

Treacle. The dark syrup known as treacle is a residuum in the manufacture of sugar, and it is a puzzle to etymologists to account for the transference of the name of a medicinal confection to a domestic article like treacle. The transference has taken place within the last 200 years. It is curious to note that the medicinal reputation of sugar and treacle has quite dwindled away. Sugar, it is true, is used in medicinal syrups, but only as a preservative or flavouring agent, while treacle has been replaced, even in the delectable brimstone and treacle, by the more refined golden syrup, which, however, lacks the slightest suspicion of the laxative action possessed by the old-fashioned treacle.

Varieties. There are many varieties of sugar cane known, the principal ones being the Mauritius, the Laina, the Otaheite, the Bourbon, the Ribbon, the Java, the China, the Singapore, the Indian, and Cristalline. Some of these are probably distinct species, such as the China sugar cane; the others differ from each other in the colour and hairiness of the stem. Some varieties are preferred in certain situations, the Cristalline cane, for example, having a reputation as a disease resister in the French West Indies. The Bourbon cane was originally introduced into the West Indies from the Isle of Bourbon. The varieties most in request are long-jointed canes, the leaves from which are readily detached from the stem as they die. As a rule, however, it may be taken for granted that each country has produced a special variety of cane suited to its climate and soil.



1. SUGAR CANES

The sugar cane grows in a wide range of climatic conditions, but flourishes best in high latitudes on account of the greater length of the days. Proximity to large bodies of water is favourable because the plants obtain the rays of light reflected from the surface of the water in addition to the direct rays of the sun. Light is essential to the storage of sugar by plants, the erect habit of the sugar cane having an important influence

in obtaining the maximum of sunlight. Frost is harmful to the sugar cane.

What the Cane is Like. The sugar cane is perennial, and produces a stem 8 ft. to 12 ft. high and 1 in. to 2 in. thick, while there are from 40 to 60 joints. The leaves are produced at the joints, and are 4 ft. to 5 ft. long and 2 in. wide. As the canes grow the lower leaves dry up, fall off and are removed, the process being known as *trashing*. The sugar cane needs a fertile soil, clay and sandy soils being unsuitable. In French Guiana the only remunerative cultivation of the sugar cane is on low lands that are periodically manured by flooding with water from which black mud is deposited. In Queensland land of virgin soil is prepared by light ploughing to get rid of grass. The ground is then ploughed 9 in. to 10 in. deep, and worked with the harrow and roller to ensure sufficient soft mould for the plant.

Propagation. The sugar cane is propagated from cuttings or seed, but usually by the former method, seed being only used for obtaining new varieties. The cuttings may be either from the top or from the body of the cane, and recent experimental work in the Mauritius seems to indicate that the tops are preferable. If *tops* be used the leaves should be stripped from two or three buds so that they can come into immediate contact with the soil. If *plant canes* be used they should be cut into lengths of three buds each, care being taken not to injure the buds. The plants are then placed in drills at a distance of about 3 ft. from centre to centre. The canes are placed horizontally and with the buds pointing one way; 1 in. to 1½ in. of mould above the cutting is quite sufficient, since it will grow more rapidly than if planted deeper. After a few days, according to the weather, rootlets will spring from the joint surrounding the bud, and in from 10 to 21 days the buds will appear above the ground.

Cultivation. All the cultivation afterwards required will be to keep the ground open and clear of weeds as long as the horse-hoe can be used, after which the ground can be left until crushing season. Cutting of the cane is effected in several ways—some are cut with a knife, the cane being trimmed and topped while in the hand, while others are cut with a sharp hoe, the trimming and topping being done by another group of labourers. When the cane is light upon the ground or stands erect the former mode seems preferable, but where the crop is very heavy the latter method is used. In either case care should be taken to cut the cane close to the ground, as the *ratoon* (the cane which springs up from the stump) will rise from the highest bud on the cane root left, and if this be not below the surface support against the wind for the young cane will be lacking. The practice of different plantations varies in regard to replanting or growing from ratoons, for although cane will retain and yield crops for several years without replanting, ratoon crops are not so heavy as plant cane. The labour supply is a factor that has to be taken into account in this connection.

Manures. We now come to consider the various manures that are necessary. *Phosphatic manures* give considerable and very remunerative increase when used together with manures containing nitrogen and potash. Phosphate slag seems to be an excellent source of phosphorus for cane plantations, and ought to replace superphosphate. Nitrogen in the form of sulphate of ammonia, nitrate of soda, and dried blood shows a favourable influence on the yield. The best results obtained by the authorities of the Botanical Gardens of British Guiana were obtained with a mixture of one-third nitrate of soda and two-thirds sulphate of ammonia, although for large quantities sulphate of ammonia gives a better pecuniary result. Dried blood was notably inferior. Potash seems to be of only small efficacy. The employment of sulphate of potash on land not limed gave a slight benefit, but a loss on limed soils. The use of soda did not furnish satisfactory results. The employment of lime gave great increase of yield, the effect on the first crop being sufficient to pay the cost of its application, while the increase in the shoots constituted a net gain.

Diseases of the Cane. The cane is subject to a variety of animal and vegetable pests. In the first category are included rats. These are kept down by poison or the use of Danysz virus. The mongoose was introduced into Jamaica to kill the rats, but ultimately became as great a pest as the rats. Among insects the moth-borer is prevalent, and is only got rid of by systematically collecting the moth and destroying the diseased canes by fire. Several other borers are known, some of the pests making special attacks on the roots of the cane. Spraying with paraffin emulsion is recommended for destroying some of the small insects. Vegetable or fungoid pests, such as red smut, top rot, serch, ananas, and gumming disease, attack the leaf and stem. The remedies are to choose canes known to be disease resistant, to correct errors of cultivation, and to destroy all affected canes by burning. Rotation of crops and green manuring are also suggested as a means of combating fungoid diseases.

Yield and Composition. The weight of crop varies very much, from 70 to 80 tons having been taken from rich scrub lands in North Queensland. A fair average is 25 to 40 tons per acre, and with modern appliances and methods a ton of sugar is sometimes made from little more than 10 tons of cane.

There is 16 to 18 per cent. of sugar present in the sugar cane and about 70 per cent. of water. The sugar is distributed irregularly throughout the cane, the joints and the lower end being poorer in sugar than the higher parts of the stem. The softer parts of the cane contain the purest and richest juice, there being altogether about 88 per cent. of juice in the cane. The juice contains about 18 per cent. of sugar, the rest being water and a small proportion of mucilaginous, resinous, fatty and albuminous matters, and mineral salts.

Continued

A SHORT DICTIONARY OF TERMS USED IN SUGAR-MAKING

ANIMAL CHARCOAL, or CHAR—Charcoal made from bones and used for decolourising sugar.

BAGASSE—Refuse cane after the juice has been extracted.
Basket Sugar—A small-grained sugar sold in the Straits Settlement.
Battery—A row of evaporating pans as used in the Jamaica sugar-industry.
Black-strap—Refuse molasses.
Blow-up—The pan in which sugar is dissolved or melted in sugar refining.
Bull's-eye—The sight-hole of a vacuum pan.

CARAMEL—Burnt sugar used as a colouring agent.
Carbohydrates—Scientific term for the group of organic bodies to which sugar belongs.
Carbonatation, or Carbonation—The process of saturating limed beet-juice or cane-juice with carbonic acid gas.
Chancara—A small-grained sugar sold locally in Mexico.
Char Cistern—Large tank filled with animal charcoal.
Clairce—French term for a saturated solution of pure sugar.
Clarification—The process of purifying raw juice by heat and lime.
Claying—The process of driving out the colour of a sugar-loaf by damp clay or rag.
Cleare—Bright, clear syrup used in liquoring sugar.
Coffee Sugar—An especially pure, refined sugar.
Concretor—An evaporating apparatus for cane juice.
Conveyor Cylinder—The large rotating cylinder of a Hersey granulator.
Copper Wall—Battery of open pans used for concentrating cane juice.
Corn Syrup—Glucose in a liquid state made from maize.
Cosettes—French term for beetroot slices.
Crystallisation—The property which many bodies have of assuming definite solid forms out of a saturated solution.
Crystallisation in Motion—The name applied to the method of crystallising the massecuite by keeping it moving during cooling.
Cube Sugar—Sugar moulded into the form of a cube.
Curing—Cleansing sugar crystals by washing and draining.
Cush-cush—Name given in Guiana to the impurities in the juice from crushed sugar-cane.
Cut—The technical expression for half-emptying the vacuum pan when discharging massecuite.

DATE HONEY—A name sometimes applied to palm sugar.
Defecation—The process of removing, by heat and lime, the fecular matter from raw juice.
Defibrator—A mill that pulps the sugar-cane.
Demerara Sugar—Sugar of a yellow colour, produced in the West Indian Islands.
Dextrin-maltose—An unfermentable substance prepared by the action of acid on starch.
Diffusion Process—A method used in beet and cane sugar manufacture by which the beetroot in slices, or the cane in small pieces is macerated in hot water to soak out the sugar.
Do-kat—The second flow of sap after tapping the date-sugar palm.
Double—A term used in sugar boiling when half the charge in the pan has been emptied and fresh portions of syrup admitted.
Double Carbonating—When the process of carbonating is done twice on the same juice.
Double Effect, or Effet—An evaporating apparatus consisting of two vacuum pans working together but at different internal pressures.
Drained Sugar—Sugar from which the molasses has been drained in hogsheads.

FALSE GRAIN—An expression used in sugar boiling when small grains of sugar separate instead of growing on the larger crystals already formed.
Film Evaporators—An apparatus which depends on the principle of evaporating a thin film of liquid.
First Molasses—That obtained from massecuite, which has had no molasses added to it.
First Sugar—Massecuite after treatment in the centrifugal machine.
First Throwing—Refined sugar purified in a centrifugal machine.
Fruit Sugar—Levulose.

GASED — The process of passing sulphurous acid gas through raw juice.
Glucose—Dextrose, or grape sugar.
Golden Syrup—The finer kind of treacle.
Grain—The small crystals of sugar that form when syrup is being concentrated in a vacuum pan.
Green Syrup—The syrup that drains from sugar-loaves in the mould.
Grocery Sugar—Moist brown sugar.
Guarapo—Raw liquor treated with lime, but not yet concentrated.

HEATER—The vessel into which the massecuite is received when discharged from the vacuum pan.
Hydro Extractors—Another name for centrifugal machines.

INVERT, or INVERTED SUGAR—Sugar the behaviour of which in the polariscope has been changed from right to left.

JAGGERY—A raw sugar produced in India, obtained from the palm.
Jarra—The third flow of sap after tapping the date-sugar palm.
Jiran—The first flow of sap resulting from tapping the date-sugar palm.

LÆVO SACHARRUM—Invert sugar used as a malt adjunct in brewing.
Levulose—Fruit sugar.
Liming—The process of adding lime to raw juice.

MACERATION—The process of soaking beet slices or cane in hot water to extract the sugar.
Maize Sugar—Sugar obtained from the stalks of zea mays.
Maple Sugar—Sugar made from the sap of the maple tree.
Massecuite—The finished mass of sugar crystals and syrup formed on concentrating syrup in a vacuum pan.
Megass—Cane after it has been pressed in the cane mill.
Melting—The term for dissolving sugar in water.
Molasses—A drained syrup from which sugar no longer crystallises on boiling.
Monte-jus—A pump for raising juice.
Multiple Effect, or Effet—An apparatus for evaporating syrup in which two or more vacuum pans, working at different pressures, are employed.
Muscovado—Raw sugar from which the molasses has been drained in tubs.

PANELA—A small-grained sugar sold locally in Central America.
Pilé—French term for white powdered sugar.
Premier Jet Sugar—Sugar purified in a centrifugal machine.
Proofstick—An instrument for withdrawing a sample of the contents of the vacuum pan.

RATOONS—The second crop of canes from one planting.
Raw Sugar—Unrefined massecuite after treatment in the centrifugal machine.
Refined Sugar—The finer qualities of sugar manufactured from raw sugar at central refineries.
Rendement—The net amount of crystal sugar obtainable from a given sample of raw sugar.
Revivification—Process of renewing animal charcoal that has become exhausted as a decolouriser of sugar.

SACCHARINE—Invert sugar, also applied to a sweetening agent obtained from coal-tar.
Saccharimeter—An optical instrument for measuring the amount of sugar in solution.
Shaker—Indian term for cane sugar clarified by alkalies.
Schnitzel—German name for beet slices.
Second Molasses—That which drains from massecuite that has had molasses boiled with it.
Seeding—Grain sugar added to the vacuum pan to start crystallisation.
Selecting—Process of improving the quality of beetroot, by always using only the best plants.
Semoule—French term for grain sugar.
Silo—Storing place for beetroots [see Agriculture, page 1970].
Sling—Name given to the concentrated syrup in the striking teach.
Starch Sugar—Glucose, or dextrose.
Steaming Out—Process of washing out hogsheads with steam, to remove adhering sugar.
Stirred Sugar—Prepared by evaporating syrup, and stirring until a dry, crumbly mass remains.
Striking Pan, or Teach—The end of a series of pans, in which the more concentrated liquor collects.
Sucrose—Cane or beet sugar.
Sugaring Off—The process and season for tapping maple trees.
Sweet Waters—Waters containing small quantities of sugar.

TATHES or TAYCHES—The pans of the copper wall.
Taylor Filter—A filter in which a large number of long filter bags are employed.
Teaches—The pans of the copper wall.
Tempering—The operation of adding lime to raw juice.
Third Molasses—The molasses drained from vacuum pan molasses sugar.
Trash—Dry cane leaves.
Trashing—The operation of removing dry or faded leaves from the sugar-cane.
Treacle—The uncrystallisable part of sugar produced in the process of refining sugar.
Triple Effect—An evaporating apparatus, consisting of three vacuum pans worked together at different pressures.

ULTRAMARINE—A blue substance used for neutralising the yellow colour of refined sugar.

VIDE-JUS—An emptying pump.
Vinasse—The residuary liquors resulting from the extraction of sugar from molasses.

WHITE LIQUOR—Bright white syrup used for liquoring loaf sugar.
Windrowing—Protecting cut canes from frost by a furrow.

YELLOW CRYSTALS—Sugar dyed to imitate Demerara sugar.

Group 8
DRAWING
26
TECHNICAL DRAWING continued from page 3641

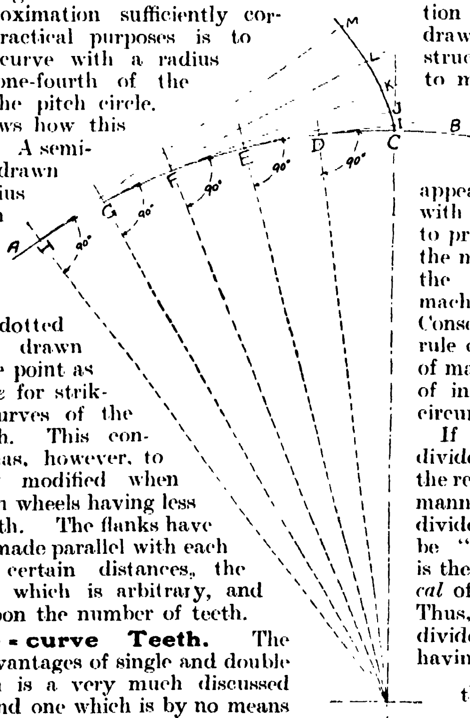
PROPORTIONS OF SPUR GEARS

Single-curve Teeth. Machine-cut Gears. Diametral Pitch. The Strength of Teeth. The Arms, Rims, and Bosses of Spur Wheels. Gear Wheel for Electric Tramcar

By JOSEPH W. HORNER

Single-curve Teeth. The method of constructing the involute curve of a *single curve tooth* is shown in **95**, where A B is the pitch line. First mark off the equidistant points D E F G H, and from each point draw a tangent to the circle; then set off the distance D I equal to the arc D C, E J equal to E C, F K equal to F C, G L equal to G C, H M equal to H C, and a curve drawn through the points I J K L M will be the involute required. It is, in effect, a curve formed by the unwinding of a cord from the arc of the circle.

An approximation sufficiently correct for practical purposes is to strike the curve with a radius equal to one-fourth of the radius of the pitch circle. Fig. **96** shows how this is arranged. A semicircle, A, is drawn on the radius of the pitch circle, and the centre, B, is located upon it; a dotted circle is drawn through the point as a *base circle* for striking the curves of the other teeth. This construction has, however, to be slightly modified when dealing with wheels having less than 30 teeth. The flanks have then to be made parallel with each other for certain distances, the amount of which is arbitrary, and depends upon the number of teeth.



95. INVOLUTE CURVE

Double-curve Teeth. The relative advantages of single and double curve teeth is a very much discussed question, and one which is by no means settled. The practice in England has been for many years distinctly in favour of double-curve teeth, due, no doubt, to the wide adoption of the odontograph instrument, together with an exaggerated idea of the theory that single-curve teeth cause undue pressure upon the shaft bearings. The tendency at present is to adopt the single curve universally, and this has been brought about largely by the introduction of *machine-cut* gears.

When toothed gears of a very fine pitch are required, it has been the practice to cut the tooth spaces from a solid rim, in order to attain sufficient accuracy to ensure quiet running. It has been left to Messrs. Brown & Sharpe, of America, to develop this idea, and to standardise the forms and proportions of machine-cut gears of all sizes and pitches. The Brown & Sharpe involute gear cutters are now used regularly all over the world, and are as much recognised as a standard article as the Whitworth and the Sellars screw threads are in their sphere. Gears having cast teeth are, of course, still widely used, but for all accurate and high speed work cut gear has the monopoly.

Diametral Pitch. The basis of calculation for cut gears is the *diametral pitch.* When drawing wheel teeth on paper, or when constructing a pattern, it is convenient and natural to measure the pitch of the teeth on the circumference of the pitch circle, and such a measurement is termed *circular pitch.* Now, when dealing with cut gears, this method of measurement disappears. The pattern-maker is not concerned with the spacing of the teeth—he simply has to prepare a wheel blank of a certain *diameter*; the machinist has to turn the blank casting to the correct *diameter*, and the gear-cutting machine is set to cut a certain number of teeth. Consequently, circumferential measurements by rule or compass are not required in the process of manufacture. Therefore, the pitch is spoken of in terms of the diameter instead of the circumference of the wheel.

If the circumference of a pitch circle be divided by the number of teeth in the wheel, the result will be "circular pitch." In the same manner, if the diameter of the pitch circle be divided by the number of teeth, the result will be "diameter pitch." The *diametral pitch* is the reciprocal of diameter pitch. The *reciprocal* of a number is 1 divided by that number. Thus, the reciprocal of 4 is $\frac{1}{4}$, because $\frac{1}{4}$ will divide into 1 four times. Now if we take a wheel having 48 teeth and a pitch diameter of 12 in., the diameter pitch is $\frac{12}{48} = \frac{1}{4}$ in., and the diametral pitch is $1 \div \frac{1}{4}$ in. $= 4$. In other words, diametral pitch is the number of teeth per inch of diameter of pitch circle; this idea may be a little difficult to grasp at first, but the following calculations will show the simplicity of its application.

To find the pitch diameter of a wheel having, say, 94 teeth of 3 diametral pitch: Divide the number of teeth by the diametral pitch: $\frac{94}{3} = 31{\cdot}33$ in. $= 31\frac{11}{32}$ in. pitch diameter. [See Table of Decimal Equivalents for Vulgar Fractions on page 3006.]

To find the diameter of a wheel blank to cut, say, 94 teeth of 3 diametral pitch: Add 2 to the

number of teeth and divide by the diametral pitch: $\frac{94+2}{3} = 32$ in. diameter of blank, or *whole diameter of wheel*, as it is sometimes termed.

To find the diametral pitch of a wheel having, say, 60 teeth, and of 24 in. diameter: Divide the number of teeth by the diameter of the pitch circle: $\frac{60}{24} = 2\frac{1}{2}$ diametral pitch.

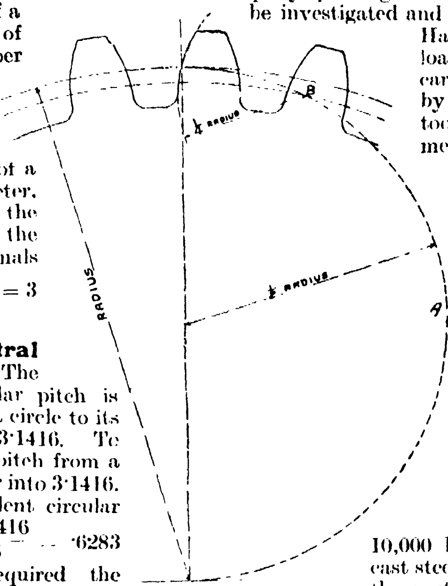
To find the diametral pitch of a wheel, say, 20 $\frac{21}{32}$ in. whole diameter, and having 60 teeth: Add 2 to the number of teeth, and divide by the wheel diameter (convert to decimals by table on page 3006): $\frac{60+2}{20\cdot66} = 3$ diametral pitch.

Relation of Diametral Pitch to Circular Pitch. The relation of diametral to circular pitch is the relation of the diameter of a circle to its circumference, which equals 3·1416. To obtain the equivalent circular pitch from a diametral pitch, divide the latter into 3·1416. Example: Required the equivalent circular pitch to 5 diametral pitch: $\frac{3\cdot1416}{5} = \cdot6283$ circular pitch. Conversely, required the equivalent diametral pitch to $1\frac{1}{2}$ in. circular pitch: $\frac{3\cdot1416}{1\cdot5} = 2\cdot0944$ diametral pitch.

A table is given on the next page showing the equivalent circular pitches for diametral pitches from 1 to 50. The Brown & Sharpe involute teeth may be set out generally as described for **96**, the proportions being as follows:

Height of tooth from pitch line, ·3183 circular pitch. Width of tooth on pitch line, ·5 circular pitch. Depth of tooth below pitch line, ·3683 circular pitch.

Strength of Spur Teeth. The strength of spur-wheel teeth may be calculated upon two bases; the one by considering a static load to be sustained by the tooth, and the other by considering the horse-power to be transmitted. For slow-moving machinery, it is convenient to estimate the load which comes on the wheel teeth, and to assume that this load is applied at the point of one tooth; the case is then treated as a simple cantilever loaded at the outer end. If the teeth are badly made, or if the wheels are not properly adjusted on the shafts, the load may come on one corner of the tooth instead of being distributed evenly across the face. Many formulæ in use deliberately assume such to be the case in ordinary work; but with modern machine-moulded or machine-cut gears there is no necessity to make such provision. The number of teeth in gear at the same moment will make a difference to the carrying capacity of a wheel; with large wheels of fine pitch gearing together, several teeth will divide the load between them; but if a small pinion be geared with a wheel, the full load may easily come on one tooth only.

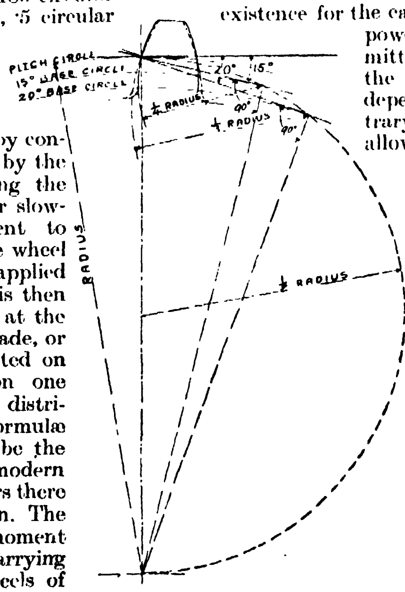


96. METHOD OF MARKING OUT AN INVOLUTE TOOTH

Properly speaking, each individual case should be investigated and designed accordingly. Having determined the load which the tooth must carry, multiply that load by the full depth of the tooth for a bending moment; the modulus of a rectangle is $\frac{B H^2}{6}$ where B is the breadth or face of the tooth, and H is the thickness at the root: multiplying the modulus by the safe stress per square inch gives the moment of resistance of the tooth, which should be equal and opposite to the bending moment. A safe stress for cast iron is 3,000 lb. per square in., and 10,000 lb. per square in. for cast steel. [See the table on the next page.]

The thickness at the root of an odontograph tooth varies from ·4 to ·6 of the circular pitch when ranging from 15 to 60 teeth. The breadth or face of a toothed wheel may vary from one and a half to three times the circular pitch.

There are from 40 to 50 different rules in existence for the calculation of the horse-power which may be transmitted by toothed gearing, the majority of them depending upon an arbitrary factor which covers allowances for inaccurate workmanship and stresses due to centrifugal action. A safe rule is $H P = \frac{D P F N}{1000}$, where D = pitch diameter of wheel in inches, P = circular pitch, F = face of wheel in inches, N = speed of wheel in revolutions per minute.



97. THE ANGLE OF OBLIQUITY

The Wilfred Lewis Formula. This is used largely in connection with machine-cut gear. It was introduced by Mr. Wilfred Lewis

No. of Teeth.	Factor for Strength, Y. Involute 20 deg. Obliquity.	Involute 15 deg. and Cycloidal.	Radial Flanks.	No. of Teeth.	Factor for Strength, Y. Involute 20 deg. Obliquity.	Involute 15 deg. and Cycloidal.	Radial Flanks.
12	·078	·067	·052	27	·111	·100	·064
13	·083	·070	·053	30	·114	·102	·065
14	·088	·072	·054	34	·118	·104	·066
15	·092	·075	·055	38	·122	·107	·067
16	·094	·077	·056	43	·126	·110	·068
17	·096	·080	·057	50	·130	·112	·069
18	·098	·083	·058	60	·134	·114	·070
19	·100	·087	·059	75	·138	·116	·071
20	·102	·090	·060	100	·142	·118	·072
21	·104	·092	·061	150	·146	·120	·073
23	·106	·094	·062	300	·150	·122	·074
25	·108	·097	·063	rack	·154	·124	·075

at Philadelphia, U.S.A., in 1893. He assumes that the whole load is taken upon one tooth, and that the tooth is a cantilever loaded at one end. From a consideration of various sizes of involute and cycloidal gears he selects the weakest cross section of each, and determines its relation to the pitch; then from these data deduces the formula W = S P F Y, where W is the load transmitted in pounds, S is the safe working stress per square inch in pounds, P is the circular pitch, F is the face of the tooth in inches, and Y is a factor varying with the shape and number of teeth. The values of Y and S are given in the table on this page.

It will be noticed in the table that the involute is given as 20° and 15° obliquity; the angle of obliquity is measured between a horizontal line cutting the pitch circles at their point of contact and a line drawn perpendicular to the curve of the tooth, and being a tangent to the base circle. Fig. **97** shows the effect on the thickness of the tooth due to an alteration in the angle of obliquity; the greater the angle the stronger the tooth. A 20° obliquity gives a tooth radius of about one-third the pitch circle radius.

When drawing gears to be cut with Brown & Sharpe cutters the angle of 15° may be taken.

Arms of Spur Wheels. These are made oval section [**98**], cross section [**99**], or H section [**100**]. The first-mentioned is used for comparatively light machine-cut gears, the second is used chiefly for gear wheels moulded from patterns, the third is adopted for machine-moulded wheels and for large and heavy gears. Frequently machine-cut gears are made with solid web plates without arms. The strength of a wheel arm may be calculated in the same way that we dealt with pulley arms. For the cross arm section the following proportions give good results:

Thickness of rim (A) .. = ·46 circular pitch
Width of arm (B) .. = circular pitch × 2
Depth of rib (C) .. = circular pitch
Thickness of arm (D) .. = ·43 circular pitch
Thickness of arm (E) = ·5 circular pitch
Thickness of boss (F) .. = ⅓ of shaft diameter + ¼ in.

The above dimensions apply at the centre of the arms, the taper being about ⅜ in. per foot either way. The number of arms in a wheel may be taken as:

Up to 1 ft. 6 in. diameter .. .. 4 arms
Up to 8 ft. diameter .. .. .. 6 arms
Above 8 ft. diameter .. .. .. 8 arms

TABLE OF DIAMETRAL AND CIRCULAR PITCHES.

Diametral Pitch.	Circular Pitch.	Diametral Pitch.	Circular Pitch.
1	3·1416	15	·2094
1¼	2·5133	16	·1963
1½	2·0944	17	·1848
1¾	1·7952	18	·1745
2	1·5708	19	·1653
2¼	1·3963	20	·1571
2½	1·2566	22	·1428
2¾	1·1424	24	·1309
3	1·0472	26	·1208
3½	·8976	28	·1122
4	·7854	30	·1047
5	·6283	32	·0982
6	·5236	34	·0924
7	·4488	36	·0873
8	·3927	38	·0827
9	·3491	40	·0785
10	·3142	42	·0748
11	·2856	44	·0714
12	·2618	46	·0683
13	·2417	48	·0654
14	·2244	50	·0628

The proportion for H arms may be taken as follows:

Thickness of rim (A) = ·375 circular pitch
Depth of rib (B) .. = A + ·01 pitch diameter
Width of arm (C) .. = circular pitch + ·035 pitch diameter
Thickness of web (D) .. ·375 circular pitch
Thickness of flange (E) = ⅛ of breadth of tooth
Thickness of boss (F) = ⅓ of shaft diameter + ¼ in.

The remarks concerning the taper and the number of arms for cross section arms apply equally to H arms. It will be noticed that in the cross and H section arms that the face of the wheel is slightly wider than the width of the arms, this giving a better appearance to the wheel

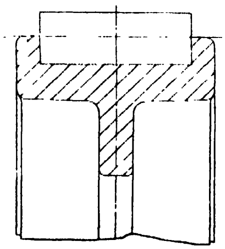
SAFE WORKING STRESS FOR DIFFERENT SPEEDS.

Speed of Teeth in Ft. per Minute.	100 or Less	200	300	600	900	1,200	1,800	2,400
Cast iron	8,000	6,000	4,800	4,000	3,000	2,400	2,000	1,700
Steel ..	20,000	15,000	12,000	10,000	7,500	6,000	5,000	4,300

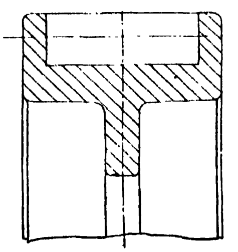
than if both were flush, and in the case of machine-cut gear it facilitates the machining of the sides.

Cast gears are frequently shrouded up to the pitch circle as **101**, full shrouded as **102**, or shrouded partially, or wholly on one side only; this adds from 20 to 50 per cent. to the strength of the gear. A common device is to shroud a pinion, but not the wheel it gears with, this being done to compensate for the unequal strength of the teeth at their roots. The thickness of the shroud may be one-third of the circular pitch.

Split Gears. Sometimes gear wheels are made in halves for convenience of renewal. A typical example is given in **103**, which represents a working drawing of a *split spur wheel* for an electric tramcar axle. It is necessary both for railway and tramway rolling stock to force the running wheels upon the axles with sufficient pressure to ensure their rigidity when negotiating a curve at high speed, for if a wheel then slipped sideways upon its axle the vehicle would be instantly derailed. Now, when the wheels are so securely fastened to an axle, it is very important that anything between them shall be removable without disturbing them, and hence the dividing of the driving spur, which is keyed to the axle between the two running wheels.



101. HALF SHROUDED TOOTH



102. FULL SHROUDED TOOTH

Looking at the drawing **103**, it will be noticed that a groove is planed across the joint of one half to receive a register formed on the other half. This relieves the bolts from shearing forces while the teeth are being cut, and also from side pressures should they occur when running. Note the section cut on A B joined by a diagonal line for the convenience of showing two sections not strictly in the same plane. In wheels of this nature it is necessary to see that they contain an even number of teeth, so as to divide properly without parting a tooth at the joint. There is no necessity to show all the teeth on the drawing. In the data given on the drawing for cutting the teeth D P of course means diametral pitch, whilst the reference to No. 2 B and S cutter means a Brown & Sharpe cutter No. 2. These cutters are made in numbers as follows:

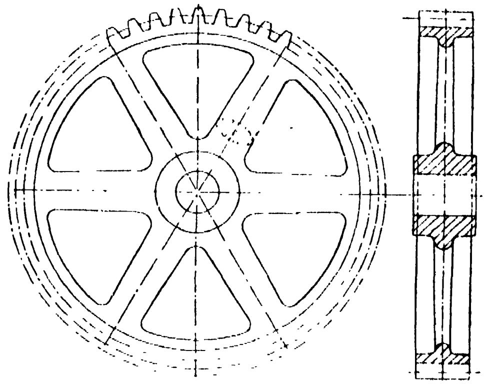
No. 1 will cut wheels from 135 teeth to a rack, inclusive.

No. 2 will cut wheels from 55 teeth to 134 teeth, inclusive.

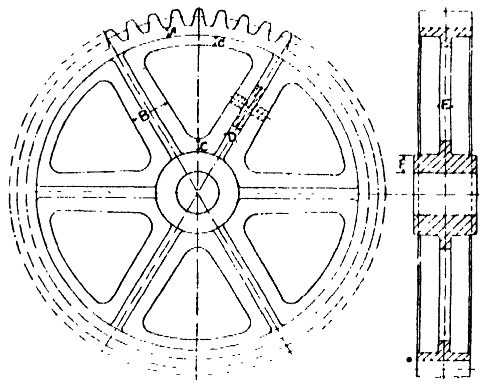
No. 3 will cut wheels from 35 teeth to 54 teeth, inclusive.

No. 4 will cut wheels from 26 teeth to 34 teeth, inclusive.

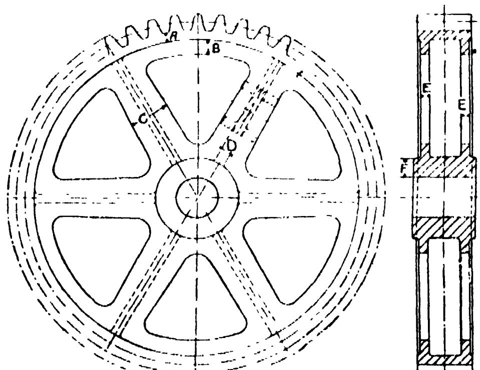
No. 5 will cut wheels from 21 teeth to 25 teeth, inclusive.



98. WHEEL WITH OVAL SECTION ARMS



99. WHEEL WITH CROSS SECTION ARMS



100. WHEEL WITH H SECTION ARMS

No. 6 will cut wheels from 17 teeth to 20 teeth, inclusive.

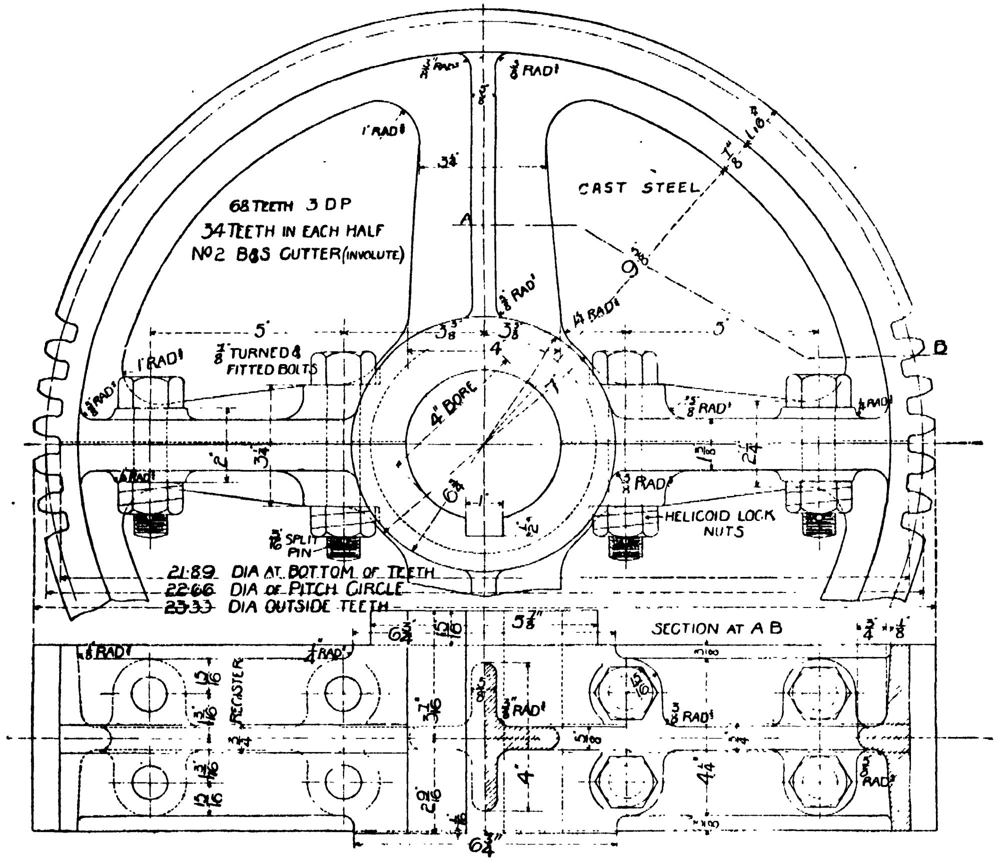
No. 7 will cut wheels from 14 teeth to 16 teeth, inclusive.

No. 8 will cut wheels from 12 teeth to 13 teeth, inclusive.

There are thus eight cutters required in order to cut a full range of teeth for any one pitch. It takes eight cutters to cut all involute 4-P gears having 12 teeth and over; it takes eight other cutters to cut all gears of 5-P having 12 teeth and over, and so forth, each separate pitch requiring its own set of cutters.

Cutters are made for cycloidal gear teeth, but are not used to the same extent as the involute. They are made in sets of 24, and are lettered steel, phosphor bronze, raw hide, etc. The construction of raw hide gears is dealt with in the next lesson together with helical teeth, mortise cogs, racks, bevils, screw gears, worms, etc.

Speeds of Wheels. The relative speeds of gear wheels may be calculated in the same way as we did with belt pulleys by using the pitch circle diameters, except that there is no loss due to slip. We may, however, simplify the calculations by using the number of teeth contained in a wheel instead of its pitch diameter. This is



103. SPLIT GEAR WHEEL FOR ELECTRIC TRAMCAR AXLE

A to X, instead of being numbered. This is done in order to avoid confusion with the involute cutters. Each set is applicable to its particular pitch only.

Large spur wheels are built up in a similar manner to that described for large rope wheels, and chiefly for the same reasons. Gear teeth are also formed upon the rims of flywheels, etc., and are used as a means of starting an engine by levers or by a small geared engine.

Gears are made in cast iron, cast steel, mild particularly useful when cut gears are involved, as their pitch diameters frequently run into vulgar fractions or decimals.

As in the case of rope wheels, there is a limiting speed beyond which gears should not be run. Cast-iron gears should not be run above 2,000 ft. per minute at the pitch line; cast-steel gears, 2,500 ft. per minute; small machine-cut gears, 3,000 ft. per minute; above these speeds, gearing becomes noisy in running, and the wear is excessive.

Continued

THE THREE RIDDLES OF LIFE

How Psychical Research is Helping to Solve them. Thought Telegraphy. Hypnotism and its Value. Modern "Miracles." Is Materialism Honest?

continued from page 3627

By HAROLD BEGBIE

THERE are two ways in which humanity has become accustomed to transfer thought from mind to mind. One is by the spoken word, and the other is by the written word. In the first case, the organ of hearing conducts the thought to the brain; and in the second case, the organ of sight.

Mental Telegraphy. It is now certain that in a third way thought can be transferred from mind to mind, and this third way has been carefully investigated by men of science, and has been termed *telepathy* for the sake of brevity, though the word does not sufficiently express the mystery.

Frederic Myers, himself the inventor of the word, confesses in "Human Personality" the inadequacy of his nomenclature: "The communication between distant persons is not a transference of thought alone, but of emotion, of motor impulses, and of many impressions not easy to define. I ventured in 1882 to suggest the wider terms *telæsthesia*—sensation at a distance—and *telepathy*—fellow-feeling at a distance. . . . But I am far from assuming that these terms correspond with definite and clearly separate groups of phenomena, or comprise the whole field of super-normal faculty. On the contrary, I think it probable that the facts of the metethereal world are far more complex than the facts of the material world, and that the ways in which spirits perceive and communicate—apart from fleshly organisms—are subtler and more varied than any perception or communication which we know."

But the term will stand, in the present state of human knowledge, as denoting all those puzzling occurrences, familiar to everybody, in which ideas have communicated themselves from consciousness to consciousness, often over great distances, without mechanical means.

An Absorbing Mystery. We would caution the reader against accepting any word, however successful its etymology, as the *explanation* of a mystery. The term *electricity* does not in the smallest way explain the mystery of electricity, and the term telepathy does not explain the mysteries it attempts to denote. There are many people who dismiss a ghost story with the verdict that it is merely a case of telepathy; they do not pause to acknowledge that the manifestation of a ghost is not one whit more inexplicable than the telepathic communication of mind with mind over a great distance.

Telepathy, one of the well-proven facts of psychical research, is an absorbing mystery. It opens up before humanity the vista of a new world, and gives promise of faculties and powers of which the most advanced of us have scarcely begun to dream. It is not a simple thing; not a mere physiological explanation of superstitious imaginings—it is a definite contribution to the study of the human mind, and one that seems to credit that mind with powers of an almost transcendental order.

Telepathy Annihilates Space. For it destroys, in the first place, as between mind and mind, all idea of space. It does not suggest, it actually proves that two minds may communicate instantaneously, though the one inhabit the western and the other the eastern hemisphere. A son dying in the Himalayas may convey his last anguish to his mother in London at the very moment of dissolution; and not only his anguish, but the very wishes in his mind concerning the distribution of his property—not merely frantic and unintelligible emotions, but definite and rational expressions of mind.

As soon as the investigator has appreciated this character of telepathy he is in a state of mind to follow the clue towards the goal of knowledge. So long as he uses the terms telepathy and coincidence merely as excuses for his own intellectual sloth, or as shields for his own ignorance—not troubling to discover what they really signify—he cannot hope to make progress in his ideas.

Now, the marvellous fact of telepathy is just this orderly transference of coherent thought. It would be wonderful if a child in its death agony should act upon the consciousness of its mother at a great distance so as to convince the mother of its distress; but it is something far more wonderful, and at the same time something inspiring us with the assured hope that we are exploring a definite faculty of human consciousness, when we find the child in its distress conveying calm and intelligible thought to its parent over thousands of miles.

Let the investigator emphasise in his mind that we are here dealing with a transference of *thought*. Thought, according to physicists, is a mental process, a cerebral action, a physical exertion; it is a movement of the brain; it is an exertion of physical energy; it is a definite and certain operation of the material brain.

The Dying Soldier's Message. Now, there are endless instances in the records of psychical research wherein coherent and unemotional messages have been received by people from those dear to them at moments of supreme crisis. A dying solider in South Africa narrated to his sister, by means of automatic writing, at the very moment of his decease, the manner of his dying, the names of comrades who held him when he fell, and expressed his wish that these two men—utterly unknown to the

sister—should receive certain gifts out of his property as keepsakes. The story is explained easily enough by the intellectually slothful as a case of "telepathy." But how do these people answer us when we venture to point out that a gentleman in South Africa, with a bullet through his spine, with his nerves torn and lacerated, with his life's blood flowing from him in a ceaseless gush, is hardly in a position to give an unemotional picture of his plight to a lady in London, and to make a rational disposal of his property? Profound thought—or, shall we say, honest thought?—must convince the fair-minded that we are here fumbling at a new door in human experience, opening upon what wonderful fields of human enterprise we dare not venture to imagine.

Proof of the Soul. The great work of Frederic Myers in this particular department of psychical research proves, we think, beyond all question the existence of a spirit, or, in other words, proves the world-old faith that man is a *soul.* He points out that in cases of this kind we have two distinct factors—the *agent*, or the person who transmits the message, and the *percipient*, or the person who receives the message. Now, the agent must first manage his own brain, and at the same time manage the brain of the percipient. The materialists have not yet got so far in their positivism as to tell us how this is done. We are left by them to inquire how the agent works in his own organism, and how he works in the organism of others. The dying soldier in South Africa, according to this theory, arranges the mechanism of his own brain for the transmission of a message, arranges the mechanism of his sister's brain for the reception of his message, and then, somehow or another, transmits it. We need scarcely pause to point out the enormous demand which this hypothesis makes on our credulity. Finite matter, which somehow or another has become conscious of itself, is able so to direct and influence each molecule of the cells of which itself is composed—is able to exercise, in Myers's own phrase, "*selective guidance of each individual molecule*"; and by some movement within itself is able to influence another lump of self-conscious matter six or seven thousand miles away with intelligible impressions and rational desires. Let him who is able, believe.

The Working of the Brain. The inquirer will notice that in many cases where thought-reading or thought-transference, as practised by "professors," has been put to the test, it has failed to convince its examiners. Myers, Sir William Crookes, and Sir Oliver Lodge have all seen experiments which convince them of genuineness, but there are innumerable instances of half-and-half success, and innumerable instances of complete and utter failure.

We find in this a reason for hoping that telepathy is an operation of spirit. The number of people who can consciously direct their brains so as to effect a telepathic message is small; the number of people who have unconsciously received telepathic messages of the most important nature is very large. It seems to us that, at the moment of dissolution, or in any moment of grave distress, the automatic working of the brain ceases, and the perturbed mind clashes on discordantly, while the spirit frees itself to express itself spiritually. Myers speaks about "the achievements of will, as it shakes itself free from the limitations which are but shadows as contrasted with its own reality."

Claims for Telepathy. This is really the clue to the mystery of telepathy—the *will.* At present we are uninstructed in the exercise of the powers of the will. "The mind of the mind," as Richard Jefferies expressed it, remains untaught. But telepathy does suggest that we are on the verge of discovering some definite law of the will. Consciousness is not so much memory as it is will—that summing-up of personality, that fifth essence of character, which is the individual of every human form. Psychical research is here found pressing upon physical science the importance of examining human personality, and of exploring the secret places of consciousness. She claims for telepathy the place of a fact in the universe, and asks philosophers whether such a fact can profitably be ignored. It is not a question of this man or that man arguing from telepathy the proof of a soul; it is a question of fact, and the work of psychical research in this respect is an emphasis of the fact.

In conclusion, we recommend to the student a careful perusal of the Report on the Census of Hallucinations, made by a committee of the Society for Psychical Research, which included in its numbers Professor and Mrs. Sidgwick, Dr. A. Myers, Mr. F. Podmore, and F. W. H. Myers. It will be found from this report that there is at least ample evidence to support the general theory of telepathy, if there be not sufficient elucidation to give to the term telepathy a significance which it sadly lacks in the mouths of the unregenerate.

Hypnotism. As soon as people perceive that psychology is the science of the outside of the mind, they become favourably inclined towards *hypnotism*, which is the science of the inside of the mind. If an intelligent savage were to see a motor-car for the first time, he might come to some more or less useful conclusions concerning it by careful observation of its behaviour; but until he had explored the interior workings of the engine he could not possibly be said to *understand* a motor-car.

Psychology is the science of observation of the mind as it manifests itself in its operations. All its distinctions between the *subjective* and the *objective* carry us but a little way in our inquiry as to the absolute reality of mind. By studying the figures on a dial and the movement of the hands we learn from a clock nothing but the time. Psychology, as distinct from experimental psychology, is a purely empirical science. An exact science of the mind must have among its methods some process of dissecting and analysing a vital brain. Such a process, we contend, is to be found in the methods of the hypnotist.

In a Hypnotic Hospital. Hypnotism has become so confounded in the public mind with the grosser nonsense of mesmerism that it is necessary to point out that the hypnotism of which we are now speaking is the hypnotism of the medical man as it is practised in French hospitals and by some of the leading physicians in London. Let the reader take his stand, as Myers says, "at one of the modern centres of hypnotic practice—in Professor Bernheim's hospital-ward, or Dr. van Renterghem's *clinique;* let him see the hundreds of patients thrown daily into hypnotic trance, in a few moments and as a matter of course; and let him then remember that this process, which now seems as obvious and easy as giving a pill, was absolutely unknown, not only to Galen and to Celsus, but to Hunter and to Harvey; and when at last discovered was commonly denounced as a fraudulent fiction, almost up to the present day. . . . Mesmer's experiment was almost a 'fool's experiment,' and Mesmer himself was almost a charlatan. Yet Mesmer and his successors—working from many different points of view, and following many divergent theories—have opened an ever-widening way, and have brought us now to a position where we can fairly hope, by experiments made no longer at random, to reproduce and systematise most of those phenomena of spontaneous somnambulism which once seemed to lie so tantalisingly beyond our grasp."

We Hypnotise Ourselves. Hypnotism, as practised by recognised men of science, consists in, first, the removal, *as far as possible*, of normal consciousness, and then the suggestion of an idea to the secondary consciousness. We say the removal of normal consciousness *as far as possible* because in many cases such hypnotists as Dr. Milne Bramwell convey their suggestions while the patient remains convinced that he has not been hypnotised at all. In most cases, however, a deep trance is induced—so deep that the patient's mind is entirely emptied of its worries and perplexities, and is free to receive and to lay hold of any suggestion which is offered to it. And yet, be it noted, hypnotism is practised by everybody in the ordinary acts of auto-suggestion which make up so large a part of that conversation which consciousness holds with itself. You cannot offer your mind an idea without, in some measure, hypnotising yourself.

The Twofold Service of Hypnotism. The services of hypnotism are twofold—first, as a curative agent; and secondly, as a means of enlarging the borders of psychology. To take the first service, that of pathological hypnotism, we find endless cases of people freed from distressing mental disorders, otherwise incurable, by the healthful suggestions of the hypnotist. In old days, a person suffering from an obsession, or being driven towards insanity by a ghost of his own conjuring, was given a tonic by his physician, and bidden to go on a voyage and see what that would do for him. To-day he is sent to the hypnotist, who induces in him a state of hypnosis, or trance, and then tells him that his obsession is delusion, that nothing threatens him, that he is perfectly well, and that he must constantly inform himself of this fact when he issues from his trance. The patient is restored to consciousness, knows nothing of what has been said to him in trance, and goes away to find his obsession gradually fading from his mind. The hypnotist, be it particularly noted, has not imposed his will upon the patient; he has merely called into activity the patient's own healthy impulses. Hypnosis, as Dr. Bramwell has pointed out, is not due to any mysterious force or fluid emanating from the operator; the condition is a subjective one: the operator calls into action powers which are latent in the brain of his patient.

Two Definite States of Consciousness. The services of hypnotism as a means of enlarging the borders of psychology have next to be considered. As we said at the outset, hypnotism is the only means we possess of analysing a vital brain. When hypnosis has been induced, the patient is not properly unconscious; his normal consciousness has been removed, his secondary consciousness is in action. You may speak to a patient and he will answer you. You may discuss a problem with him, ask his opinion of a sonata, or discuss his opinion of his own normal consciousness. His answers will be perfectly rational and intelligible; he will speak of himself—that is to say, of both his normal and his secondary consciousness—in a manner which exhibits perfect knowledge of both. But when hypnosis has passed he is unaware of what he has said, and cannot remember that he has even spoken in his trance. That is to say, while his secondary consciousness has an intimate knowledge of his normal consciousness, his normal consciousness is completely ignorant of the secondary consciousness.

No words can exaggerate the importance of this discovery. No book of psychology can hope to throw light on the system of mind which does not take account of these two definite states of consciousness. Instead of a mind expressed in consciousness, we have a mind in which normal, or waking, consciousness plays but a meagre part, and in which a secondary and unapprehended form of consciousness plays a large part. Instead of regarding consciousness as the mind in action, we have to look upon it as a fragmentary and very imperfect form of the mind's general activity.

The Mystery of Suggestion. There are many familiar legends concerning the cure of diseases which at once suggest themselves, in the light of hypnotic knowledge, as cases illustrating the power of auto-suggestion. The miracles of Lourdes, the healings of Christian Science, and the legends of King's Touch—all have, in this light, a rational explanation. But they serve a more useful purpose than acting as mere illustrations of a theory. They force us, in an extremely suggestive manner, to apprehend the deeper mystery of what we call *auto-suggestion.* If I have a toothache I naturally wish that I should not feel the pain, but wish as I may,

the pain rages. Why, then, am I to believe that the suggestion of the hypnotist will be sufficient to remove the pain which my own suggestion is incapable of affecting? Now, when we notice that in the case of the Lourdes miracles and in the case of Christian Science healings pain is undoubtedly removed, we perceive—without in any way committing ourselves to the hypothesis of the miracle—that an ecstatic perturbation, or a violent and intense emotion, has the power to effect on the physical organism results which ordinary suggestion fails to accomplish. This leads us to the conclusion which Dr. Bramwell himself holds—although combating its inference—that suggestion is not sufficient of itself to account for the effects produced by hypnotism. Suggestion does, indeed, persuade—powerfully persuade—the mind, but suggestion without hypnosis, or some other influence of a supernormal kind, is not sufficient to account for the revolution in tastes and morals, the entire change of habits and dispositions, so effectually induced by the hypnotist.

A Man Performs his own Miracles. But if we accept the definition of *suggestion* given by Myers as the *successful appeal to the subliminal self*, we are in a position to explain, at least tentatively, the cures of the hypnotist and the miracles of Lourdes. In the case of Lourdes the patient who is cured is generally of a hysterical or of a very simple nature; he believes implicitly what he is told; he is convinced that the water will miraculously cure him. His ecstasy sweeps away, more and more, the troublesome normal consciousness, until at last, when he reaches the holy waters, normal consciousness is in abeyance, and all the avenues to his soul are thrown wide open to the influences around him. So in Christian Science a formula is given which gets rid of the sceptical and discriminating normal consciousness, and slowly makes a way to the higher faculties of being, which exercise a far greater control over the mind. The higher and the more spiritual the faith, the more probable the miracle. If a man can persuade himself that a chip of wood is a piece of the Holy Rood, and that it is efficacious in all sickness, he may cure himself of disease.

Myers was led to perceive by very careful observation of these "miraculous healings" that ecstasy in some form is a common feature of will cures. This led him to think that hypnotism, without knowing it, made possible by hypnosis that successful appeal to the subliminal self which is in truth the agent of cure in every case—religious or therapeutic.

The student will study for himself the evidence on this subject, and will decide how far Myers was justified in his theory. It remains only to say that, whether any theory can yet be substantiated by the evidence before us or not, the facts of hypnotism are in themselves a definite and revolutionising contribution to the study of the human mind. It is in this attitude that we would present hypnotism to the reader as a subject worthy of his most devoted attention.

The Higher Problems of Life. To a young community, such as a colony struggling to create itself anew after the ravages of war, life seems to present to it no other concern than the material objects of existence. Even in old and settled countries there are people who can conceive of life as nothing more valuable than the opportunity for improving sanitation, devising new forms of taxation, and amending the acts and by-laws created by their ancestors.

But as soon as a man's life becomes more or less ordered, and he has advanced some way from the forest necessity of a struggle for existence; as soon, we mean, as a man has no worry about his raiment, his nourishment, and his lodging, he begins to perceive that life presents to his intelligence certain important problems which it obviously behoves him to solve if he would live a rational life.

He must know, in the first place, what he is. He must know, in the second place, the object of his existence. And, in the third place, he must know what are the effects of death upon his consciousness. It will seem to him at the moment of this apprehension that life can scarcely have a more splendid occupation for his intelligence than a solution of these problems. Instead of appearing before him mistily and uncertainly, as the by-play and the hobbies of existence, they will appear to him the grand objects of life, beside which the struggle for existence is the mere passion of youthful barbarism.

The three great riddles, "What am I?" "Why am I here?" "What happens to me at death?"—have teased the intelligence of man from the earliest dawn of consciousness. The answers have been so various as to confuse the questions, and it is only now, with a definite procedure of science at our hands, that we are able, first, to see the questions in their true significance, and, secondly, to approach them with the definite hope of their solution. We have reason to believe that the questions are not vain, and that it is the end of human inquiry that we should reach their answers.

Are the Materialists Honest with Themselves? It must sometimes strike us when we are reading a book about the brain how oddly we are constituted, since the brain is here found reading about itself in the fond hope of discovering what it is! One knows not how the materialists feel when they are composing these books; but we must suppose them to sit back in their chairs now and then, and wonder how it comes about that the lump of matter which we call the brain is able to write so learnedly about itself without in the least understanding what it all means. It seems at first sight that these men cannot be honest with themselves, that they cannot definitely believe that the facts marshalled on their manuscript, the logic running through it all, and the conclusions gradually emerging with the utmost satisfaction to themselves, are all the products of a handful of matter struggling to see itself in the mirror of philosophy. The brain

writes about the brain; the brain reads about the brain; and the more we absolutely regard the brain as this handful of matter the more are we amazed at the position.

Man is More than Matter. A very little inquiry into the labours of men who have seriously set themselves to answer the three great riddles of existence convinces us that we are dealing with subtler forces than any exercised by gross matter. We may not be able to subscribe to the conclusions they have reached, but we shall feel that these men are groping for light in the only region where light is to be found, and that already they have brought back sufficient illumination to convince us that man is something more than a material being, and that his imagination and his genius are something more than the by-products of accidental evolution.

There is one point in the methods of these men which differentiates them completely from the pronounced materialists; and it is a point of such importance that we would particularly beg the reader's attention for it. In reading the gospel of materialism the student will perceive that physical science postulates in its study of humanity, a type of being so rare that we might almost be excused for doubting that he exists at all. Man, we find, is habitually spoken of by materialists as a vigorous creature, judging from effect to cause, from cause to effect, free from all superstitions, his mind working with the handsome regularity of a steam-engine, his processes of thought running evenly, his emotions —if they ever venture to manifest themselves at all—revealing themselves only in the most orderly and pious fashion, one, in short, whose brain is absolute lord and master in the house, and whose digestion can account for any trivial aberrations in sleep which may from time to time disturb the unbroken sway of his intellect.

Hysteria and Insanity. In reading the gospel of psychical research, on the other hand, the student finds a wiser science which sets up no perfect man as the norm of the race, but which seeks for humanity where it is to be found—even in the prisons, in the hospitals, and in the lunatic asylums. In search for the secret of consciousness, psychical science goes to every form of human consciousness, and examines it patiently with the most scrupulous devotion to the well-defined procedure of physical science. It examines all those phenomena which the materialists dismiss with the meaningless word *hysteria*, and it studies all those disintegrations of personality which the materialists also dismiss with another meaningless word—the word *insanity*. There is no alienist who can tell you what insanity means; there is no physician who can tell you what hysteria means. And yet these two words are the brooms which material science is in the habit of employiug to sweep out of its survey of humanity some of the most important and suggestive aspects of human personality.

Great Men on Great Mysteries. In closing, we would draw the reader's attention to a few conclusions which have been arrived at on these great riddles by men of eminence.

In Reid's "Essay on the Intellectual Powers of Man" we read: "I am not thought, I am not action, I am not feeling; I am something that thinks, and acts, and suffers. My thoughts and actions and feelings change every moment; they have no continued, but a successive existence; but that *self* or *I* to which they belong, is permanent, and has the same relation to all succeeding thoughts, actions, and feelings which I call mine."

In Kant's "Werke," we read: "It is therefore as good as demonstrated, or it could easily be proved if we were to enter into it at some length, or, better still, it will be proved in the future—I do not know where and when—that also in this life the human soul stands in an indissoluble communion with all the immaterial beings of the spiritual world; that it produces effects in them, and in exchange receives impressions from them, without, however, becoming humanly conscious of them so long as all is well."

Dr. Alfred Russel Wallace says: "My position is that the phenomena of spiritualism in their entirety do *not* require further confirmation. They are proved quite as well as any facts are proved in other sciences . . . This being the state of the case as regards evidence and proof, we are fully justified in taking the *facts* of modern spiritualism (and with them the spiritual theory as the only tenable one) as being fully established."

An Intelligible Basis of Life. Sir Oliver Lodge says: "The mystery of incarnation and of gradual development, of the persistence of existence beyond bodily death and decay, and even some glimmerings of the possible meaning of the vague dream of so-called reincarnation, all become in some sort intelligible on a basis of this kind—the basis of a full and never wholly manifested persistent self, from which periodically sprouts a terrestrial manifestation, though never quite the same. Each terrestrial appearance flourishes and assimilates mental and moral nutriment for a time, and the result of each is incorporated in the constant and growing memory of the underlying, supporting, but inconspicuously manifesting, and at present barely recognised, fundamental self."

Frederic Myers writes: "*Spiritual Evolution*: That, then, is our destiny, in this and other worlds—an evolution gradual with many gradations, and rising to no assignable close. And the passion of life is no selfish weakness, it is a factor in the universal energy. It should keep its strength unbroken even when our weariness longs to fold the hands in endless slumber; it should outlast and annihilate the 'pangs that conquer trust.' . . . Nay, in the infinite universe man may now feel, for the first time, at home. The worst fear is over; the true security is won. The worst fear was the fear of spiritual extinction or spiritual solitude: the true security is in the telepathic law."

Psychology concluded

continued from page 3554

DAIRY CATTLE

Importance of Careful Breeding. Our Principal Native Breeds, their Characteristics and Yields of Milk and Butter

By Professor JAMES LONG

THE pure breeds of dairy cattle which may be termed British are without question superior to those of any other country; indeed, with the exception of the black cattle of Holland, generally described as Dutch, the Schwyz of Switzerland, and the dairy cow of Normandy, all of which are excellent, we know of no cattle in the world which are approximately equal to the best of our native breeds. The foreign varieties that we have named, however, although large producers, yield milk which is only of moderate quality, and this especially applies to the Dutch cattle. Denmark possesses two varieties of dairy cow, the Jydsk and the Angeler, both useful and economical, while the Belgians own an excellent race in the Flamande; but these, again, can scarcely compare with the cattle of the British Isles, or with the best of France and Switzerland.

Improvement of Breeds. Unhappily, in all countries the majority of the cows kept by farmers are of impure blood, chiefly crosses or "scrubs," which have been carelessly bred, and in many cases carelessly reared. Whether purity of breed be maintained or not, in order to achieve success in the dairy farming industry it is essential not only to maintain, but constantly to improve the milk-producing qualities, and this can only be accomplished by breeding farm stock, both sire and dam, which is of essentially deep and rich milking blood. This fact may be illustrated in the following way:

Purest, 15 lb. 4 oz. butter per week.	Mercury	Jupiter	Saturn Rhea		
		Alphea	Saturn Rhea		
	Nymphœa 18 lb. 7 oz.	Mercury Phædra, 19 lb. 12 oz.	Mercury Leda	Jupiter Europa 15 lb. 6 oz.	Jupiter Alphea

Cow A, 3 lb. butter per week	Bull 1	Bull 2	Bull 3 Cow D, 4 lb.	
		Cow C, 2 lb.	Bull 4 Cow E, 5 lb.	
	Cow B, 4 lb.	Bull 3	Bull 4 Cow G, 4 lb.	Bull 6 Cow I, 4 lb.
		Cow F, 3 lb.	Bull 5 Cow H, 3 lb.	Bull 7 Cow J 3 lb.

Thus the cow Purest, bred from the bull Mercury (a son of Jupiter and Alphea, both of high butter-producing blood, as the pedigree shows) and the cow Alphea, which had already produced high butter-making stock when mated with Jupiter, produced 15¼ lb. of butter per week. Again we see by the second pedigree that by continually using cows which were small producers and different bulls, neither of which had any "butter blood," we get produce as in "Cow A," which shows a diminished yield of only 3 lb. per week. Whereas if these cows were mated in each generation to a bull with milking blood in his veins, they would systematically produce offspring which would inherit in a more or less marked degree the qualifications which their sires possess. It is for a similar reason that the constant employment of Shorthorn bulls, which have practically no inherent value except for the production of beef, while improving the size, form, and meat-producing qualifications of the stock to which they become sire, fails to impart the milking property which is so essential on the dairy farm. On the great majority of farms calves are bred from time to time which are of little or no economical value for breeding or dairy purposes. Such animals should be converted as quickly as possible into veal, and this practice is more profitable when they arrive in the spring, and can be allowed sufficient milk at a time when its value is lowest in the market.

The Good Milking Cow. It is desirable, however, that we should not be mistaken as suggesting that milk is the only qualification in a cow. She possesses an intrinsic value apart from her deep and rich milking properties, and this is especially the case among the larger breeds, whose end is the shambles. A good milker, therefore, should possess good feeding properties, a gentle disposition, a mellow skin, square build, which combines breadth across the hips and between the buttocks, depth of body, and length, although the milker, contrary to the beef-producer, is finer in the shoulder, neck, head, and horn. Size and constitution are largely obtained by the liberal feeding of the calf, and a lesson in this direction may be advantageously taken from those breeders of stock bulls who allow their bull calves to suckle their dams, or to drink whole milk until they have completed their first year.

Our Native Breeds. The following are the chief varieties or breeds of dairy cattle in the British Islands. We have already briefly described them in the lesson on British Breeds of Cattle on page 2235, and the student should refer to the details there given, to which the following remarks are supplementary. The pedigree Shorthorn is not included, inasmuch as—although there are occasionally fine milkers—the breed is peculiarly a beef producer, as previously stated. There are also two varieties of the Devon, the one bred for meat production, the other, peculiar to the south of the county, a milker of high type [3]. Similarly there are strains of Red Polls in East Anglia which are respectively first-rate as milkers or as beef-makers. The remaining breeds are essentially milking cattle, and in most cases of little value for meat production, whether fed as young stock or fattened when their milking days have ended.

OUR DAIRY CATTLE				
Breed.	Averages.			
	Weight in lb.	Milk Yield. Gal. per annum.	Per cent. Fat of Milk.	Per Cent. Solids Not Fat.
Dairy Shorthorn	1,350	600	3·7	9·0
Devon	1,150	500	4·2	8·8
Red Poll ..	1,100	500	4·1	9·1
Ayrshire	1,000	550	3·8	8·9
Kerry	900	450	3·7	9·0
Dexter	800	450	3·5*	9·0
Jersey	830	450	4·6	9·3
Guernsey ..	1,000	520	4·5	9·2

* Average at Park Royal, 1905.

The Dairy Shorthorn. This is, perhaps, the most popular of dairy cows with the farmer. It is in this country regarded as a general purpose cow, the largest producer of milk, and capable on an emergency, or when milk production fails, of producing a heavily-meated carcase. There are Dairy Shorthorns in this country of the highest type—superior to any general purpose cow in existence—and we believe that it would be possible by careful selection not only to beat the choicest stock of any other known breed in the world for weight of milk and butter, but, by breeding from the best to be found, to produce animals which would equal the Jersey from the point of view of the quality of milk. Although the average fat percentage is not high, there are in every important competition, such as the annual contests at the National Dairy Show, Dairy Shorthorn cows whose milk contains from 4 to 5 per cent. of fat. Hence, the inherent capabilities of the breed are much greater than they are generally supposed to be.

The Dairy Shorthorn cow has deep, straight, and wide buttocks, a long, narrow head, surmounted by fine horns, usually curved inwards, a white muzzle, slender shoulders, a capacious abdomen, and a large, fine skinned, silky udder, provided with fairly large teats, placed wide apart each way, and carried well forward under the abdomen, and well backward between the buttocks. The udder should not hang, but in a good cow it is symmetrical, usually semi-globular, distended before milking, and shrunken immediately afterwards. A fine animal presents a massive appearance from behind, and a somewhat wedge-shaped form from the front. The calves grow with rapidity, and if the feeding be well maintained from birth, they provide splendid meat, known as baby beef, at two years old, instead of four years, as was the case a quarter of a century ago when cattle were kept until they became oxen. The best Shorthorn dairy cattle are found in Cumberland and Westmorland, parts of Lancashire and Yorks, and the North of England generally; in Derbyshire and Bucks there are also many fine cows of this type. In other counties the local breeds often predominate, but in all parts of England, except where poor land prevails, Shorthorns are found in the hands of a large percentage of dairy farmers. In the United States the pedigree Shorthorn is one of the popular breeds, but the Dairy Shorthorn cow, as we understand it, is almost unknown, and the great competitions in Chicago and St. Louis have proved that American farmers have little knowledge of the high value of our great native milking cattle. The following tables show their great capacities.

YIELDS OF MILK BY SHORTHORNS AT THE LONDON DAIRY SHOW			
	Owner and Cow.	In 24 hours.	
		lb.	oz.
1901	Mr. Bonster's Non-Pedigree Shorthorn	69	8
	Mr. Spencer's Model Mary	66	13
	Mr. Albert Merry's Mary ..	61	13
	Mr. George Long's Red Queen	69	8
	Mr. Skeppy's Model Maid ..	66	2
	Mr. Stanhope's Wibby ..	57	10

BUTTER PRODUCTION AT THE LONDON DAIRY SHOW			
	Owner and Cow.	In 24 hours.	
		lb.	oz.
1902	Mr. Birdsey's Honesty ..	2	11½
	Mr. Merry's Molly	2	10
1903	Mr. Merry's Daisy	3	1½
	Mr. Merry's Beatrice	2	7½

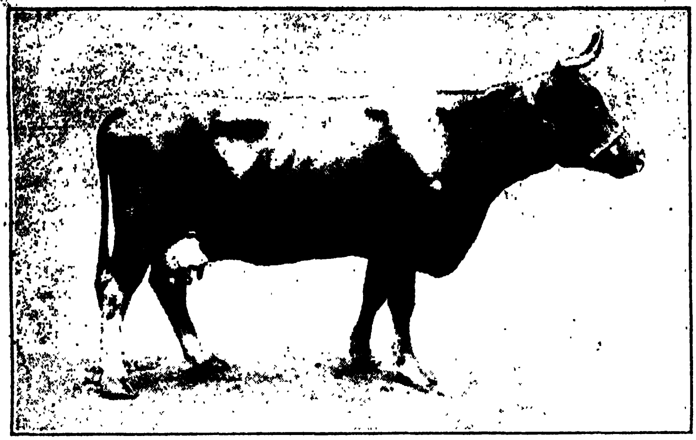
AVERAGES AT THE DAIRY SHOW MILKING TRIALS, 1899-1904			
No. of Cows.	Pounds of Milk per Cow.	Per cent. Fat.	Per cent. Other Solids.
147	48·3	3·73	8·9

Between 1895 and 1900, 106 Shorthorns were tested for butter at the Dairy Show. They averaged 50½ days in milk and 1·11 oz. of butter per day, requiring 28·8 lb. of milk for the production of each lb. In the four following years the averages were almost identical.

At the Royal Show at Derby, in June, 1906, Mr. Evens's Lincoln Red (Burton, 4st.), 6 years old, gave 68 lb. of milk; and Mr. R. Shelton's Shorthorn, Lady Mainstay, 8 years old, 7 gal. of milk in 24 hours—the latter producing 3 lb. 4 oz. of butter.

The Devon. The Devon dairy cow [3] is mellow fleshed, and in many instances symmetrically formed, but she is less perfect in this respect than the Devon of the showyard, which is bred for beef production, and wanting in those finer points which characterise the perfect dairy cow. Her milk is rich, and in many herds the yield is large and the fat percentage high, for which reason she is well adapted to the production of what is known in the West as clotted cream. She is an exceptional butter cow, but is used in Somerset by many farmers in their cheese-making herds. We may fairly assume that a herd of useful cattle will produce more than 4 lb. of butter per 100 lb., or 10 gallons of milk.

At the Royal Show at Derby (June, 1906), Mr. Wm. Vosper's Primula Second, gave 56 lb. of milk producing 2 lb. 4½ oz. of butter in 24 hours; and at the London Dairy Show, in October, 1904, the cow Primrose gave 56 lb. 2 oz. of milk.



3. SOUTH DEVON COW *Vinton*

The Red Poll. A good milking cow of this breed possesses a long head, quite devoid of coarseness, somewhat slender neck and shoulders, a capacious abdomen, square quarters, deep body, breadth across the hips, and a somewhat light fore-quarter; the udder resembles that of the Shorthorn. The following measurements are of a first-prize cow of that breed. Height of hips, 50 in.; length, 82 in.; girth behind the shoulder, 75 in.; width across hips, 20 in.; hip bone to tail, 17½ in. Although the average quality of the milk is exceptional, there are many cows which produce milk containing still larger proportions of fat.

YIELDS OF MILK AT THE LONDON DAIRY SHOW

	Owner and Cow.	In 24 hours.	
		lb.	oz.
1902	Lord Rothschild's Hastoe Gloss	50	12
	Mr. Barnet's Ruth IV.	51	—
	Lord Rothschild's Honest Wayward	56	8

BUTTER PRODUCTION AT THE LONDON DAIRY SHOW.

From 1895 to 1900, 30 cows were tested. They averaged 60½ days in milk, and 1 lb. 4¾ oz. of butter per day. In the following four years the weight of butter varied from 1 lb. to 1 lb. 8½ oz., requiring from 25½ lb. to 30¾ lb. to produce each lb.

AVERAGES AT THE DAIRY SHOW MILKING TRIALS, 1899–1904

No. of Cows.	Pounds of Milk per Cow.	Per cent. Fat.	Per cent. Other Solids.
40	40·7	3·65	8·9

The Ayrshire. This characteristic breed, so unlike any other variety in these islands, from the point of view of horn, form, and colour, is peculiarly Scotch, and cows are commonly brought by Scotch settlers to England, while they are frequently exported to Norway and Sweden, where they are much esteemed. The Ayrshire is a hardy cow, adapted to feed on the mountain-side, and to make the most of a coarse ration. Although weighing fairly well, she is smaller in frame than the figures suggest. In addition to the remarks made on page 2236, we would call attention to the fact that in no breed do we find the shoulders and neck so slender, or the body taper so gradually from the fore to the hind quarters [see illustration on page 2237]. The abdomen is large, the loins thick and deep, and the udder exceptional in its form. Instead of hanging or being globular, it is comparatively flat, sometimes no deeper than the base of the abdomen, but it is broad and long, and provided with four small teats, which fit it for female rather than for male milkers. The breed should be more generally encouraged in England, although it is probable that English farmers object to it on account of its being but little adapted to the production of beef. The Ayrshire is found in perfection in the South-West of Scotland, chiefly in the two great cheese-producing counties of Ayrshire and Wigtonshire, where herds containing 250 head may sometimes be found, since it is better adapted for cheese-production or milk-selling than butter-making. A London champion cow measured as follows: Height at hips, 50 in.; length, 84 in.; girth behind shoulder, 74½ in.; width across hips, 18 in.; hip bone to tail, 18 in.

In the milking trials of 1899 four Ayrshires averaged 47¼ lb. of milk containing 3·7 per cent. of fat and 9·2 per cent. of other solids. In 1901 four cows averaged 42·3 lb. containing 3·4 per cent. of fat and 8·9 per cent. of other solids.

In the years 1896 to 1900, eight Ayrshires averaging 52 days in milk averaged 1 lb. 13¼ oz. of butter, each lb. requiring 26·35 lb. in its production.

The Jersey. The Jersey is at once the most elegant of our native breeds, and the most beautiful in colour, which varies from fawn and golden fawn to silver grey and mulberry [see illustration on page 2237]. She is a small cow, less fleshy than any other British variety; her skin, which should be thin and silky, covers its bony structure with little flesh behind it. Many judges incline to this want of fleshiness, and in some cases a belief is held that the fleshy cow is not a meritorious milking cow. Dr. Watney, however, the most successful of all competitors in butter-making competitions, has proved by constantly beating all rivals that this theory is not correct, for he maintains his cattle in a comparatively meaty condition, and turns them into pastures as luxurious as those upon which the pedigree Shorthorn breeders of the past obtained the high condition in which their stock was usually shown. The Jersey has a particularly fine head and muzzle, which, like her tongue, is black, a small delicately formed, crumpled horn, curving inwards, yellow at the base, and black

at the points. The skin is mellow and oily, the shoulder almost imperceptible, the back straight, the ribs well sprung, the hips wide, the belly capacious, and the buttocks wide apart, the gap being filled with the back of the large and globular udder, which is more characteristic of this breed than of any other; the teats are of medium size, well placed, and wide apart. The milk vein is prominent, the tail black and long, and the skin yellow and rich in the most exposed parts, as the ears, inside the thighs, and the udder. The Jersey is a remarkable milk and butter producer, and the few selected examples will furnish some idea of her capacity. Baron's Progress, London champion (1889) gave milk containing 7·94 per cent. of fat in the morning, and 8·55 per cent. in the evening, producing 3 lb. 5 oz. of butter in a single day.

Between 1895 and 1900, 126 Jerseys, averaging 99 days in milk, produced an average yield of 1 lb. 10¼ oz. in the 24 hours, 19·15 lb. of milk being required in the production of each lb. In 1903, 20 cows averaged 1 lb. 11 oz. of butter, each lb. being obtained from 18·12 lb. of milk. In 1904, 12 cows in milk 117 days gave an average yield of 1 lb. 13½ oz. of butter, each lb. being produced from 19·6 lb. of milk.

AVERAGES AT THE DAIRY SHOW MILKING TRIALS, 1899–1904

No. of Cows.	Pounds of Milk per Cow.	Per cent Fat.	Per cent. Other Solids.
131	31·4	5·2	9·2

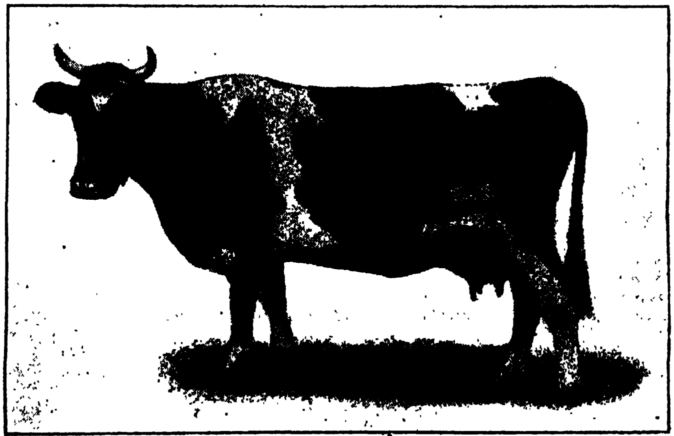
Not only is the milk of the Jersey rich, but it is remarkable for the large size of its fat globules, as well as for the extraordinary richness of its colouring, which, like that of other breeds, is more marked when the cows are on the pastures in summer. Much has been done in the Island of Jersey, from which all our stock is derived, as well as in England and America. In the latter country there are many public tests of remarkable cows, and the pedigrees of these animals are often accompanied by figures showing the actual yield of butter by the dams and the grandams during a given period. As the Jersey has little economical value apart from her milking powers, it is more than essential that this should not only be maintained, but developed by the adoption of the principle of selection.

The male calves of the Jersey, unless of very first-rate stock, are of little or no value, and the remark applies equally to heifer calves the produce of inferior cows and bulls. In every important exhibition animals are exhibited which have been purchased in the Island of Jersey from breeders who realise high prices for cattle able to win. The English Jersey is usually a bigger, coarser, and stronger cow than those bred in the island. She is a hardy animal, essentially profitable so long as she continues to milk, but at the end of her days her carcase carries little meat. Jersey milk is seldom placed on the market, for the reason that the dealer is unwilling to pay for it in proportion to its value. It not only produces more butter per 100 lb., but more cheese, and, contrary to the belief of the practical man, it produces better cheese, while the cream is far superior in texture and flavour to that of any other breed, the Guernsey excepted.

Dr. Watney's herd, members of which have reached 550 lb. of butter in a year, has reached an average yield per cow of 450 lb.

Measurement of Baron's Progress. Height of hips, 50 in; length, 87 in.; girth behind shoulder, 72 in.; width across hips, 56 in.; hip to tail, 20 in.

The Guernsey. This famous cow [4] is one of the chief products of the island from which its name is derived. Her colour is orange, or orange and white. She is heavier, larger, and coarser than the Jersey, and her lines in consequence less finely drawn. The quality of her milk is practically equal to that of the Jersey. It produces butter and cream of similar character and colour, and is equally well adapted to the manufacture of cheese. The average Guernsey is of a fleshier type than the average Jersey, but the lightly-clad cows, when symmetrical, are preferred by the judges in the showyard. The skin is fine and soft, the body deep, the loins wide, and the fore-quarter slender in the best examples; but, taking the breed as a whole, it is less elegant than the sister variety, although occasionally cows closely approximate in quality to the best Jerseys. The calves are better adapted for veal production than those produced by Jersey cows, and although some admirers have produced excellent steers, it is doubtful whether a net profit has been realised upon their sale. Occasionally wonderful producers of milk and butter have appeared on the scene, and the following instances show that there is inherent power in the breed, that is less ardently cultivated than the Jersey, which in this country,



4. GUERNSEY COW — Vinton

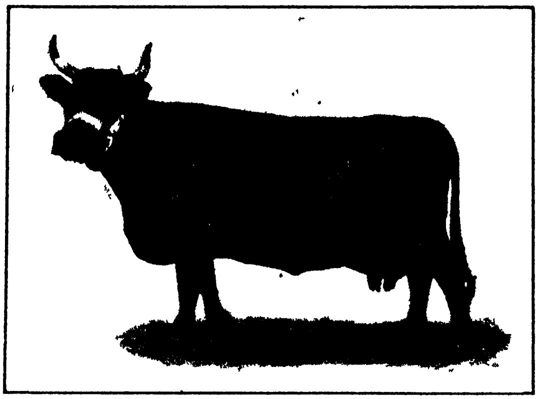
as in America, has an exceptional society of admirers behind it.

In the United States, Guernseys which have been officially tested have in many cases given from 1,200 to 1,400 gallons of milk, producing from 620 lb. to 775 lb. of butter in a year, while in the Island averages of 1,200 gallons in small herds are not uncommon.

Between 1895 and 1900, 23 Guernseys, averaging 71¾ days in milk, averaged per day 1 lb. 9¼ oz. of butter, each lb. being obtained from 21·8 lb. of milk. In later years these figures were both increased and diminished, for the number of competitors was small.

AVERAGES AT THE DAIRY SHOW MILKING TRIALS, 1899–1904			
No. of Cows.	Pounds of Milk per Cow.	Per cent. Fat.	Per cent. Other Solids.
42	31	4·5	9·1

The following measurements are of a 2½-year-old heifer which was a London champion: Height of hips, 50 in.; length, 86 in.; girth behind shoulder, 72 in.; width across hips, 18 in.; hip to tail, 18 in.



5. DEXTER COW Linton

The Kerry [see page 2237]. The Kerry cow is the pride of the dairy of Southern Ireland, where, however, it is not seen to the best advantage. Its small size is no doubt owing to the fact that it has been practically "made" on the mountains of the south-west, where herbage is extremely scanty, and the means of the owners as extremely limited. The result is that, apart from diminutive size, it remains a milker of a very low order until its venue is changed and it is supplied, like other cattle, with liberal quantities of proper food. When fed in the normal manner it is one of the best milkers in the world in proportion to its weight. The writer once attended the great Kerry Fair, at Kenmare, where, from some few thousand animals, the animal that was believed to have been the best of the bunch was selected and purchased by a fellow visitor for a five-pound note. Prices, however, are different in England, where the Kerry is much superior. The Kerry is black, or black with a little white. She is low in stature, but rather lengthy and deep in body, yet she is as graceful as she is gentle in disposition. The head is well formed, and the horns symmetrically curved. The properties of the breed adapt it to the requirements of private owners, as it will supply sufficient milk for a household, and yet the Kerry is not a butter cow of high order, for the milk, although fairly rich, does not produce butter of the finest type as regards texture, colour, and flavour when compared with the Jersey or the Guernsey.

The cow Babraham Belle has produced about 1,100 gallons of milk per annum; while at the Derby Royal Show, Lady Greenall's Walton Joyous, 4 years old, gave 47 lb. 14 oz. of milk in 24 hours.

In 1902, the only year in which the London competition has been normal, few cows having been entered, two Kerries, averaging 46½ days in milk gave per cow 1·7⅝ lb. of butter, each lb. being obtained from 21¼ lb. of milk.

AVERAGES AT THE DAIRY SHOW MILKING TRIALS, 1900–1905			
No. of Cows.	Pounds of Milk per Cow.	Per cent. Fat.	Per cent. Other Solids.
51	31·8	4	9·1

The Dexter. The Dexter [5] has no counterpart among any British breed as regards either size or form. It is wholly black or red; a little white on the udder, along the inside of the flank, or underside of the belly, or on the tassel of the tail is allowable. The head is broad and short, tapering to the muzzle, which is large; the neck is short, deep, and thick, the shoulders wide apart, the hips wide, the quarters deep and well sprung; the body well ribbed, the under loin straight and the udder placed well forward, showing breadth behind, the teats being well placed and of medium size. The legs are short and strong, and the body is as close to the ground as possible. The horns are short and moderately thick, having an inward and slightly upward curve. The skin is soft and mellow, but not too thin, while the hair is fine, abundant, and silky. The bulls should not exceed 900 lb. in weight, and the cows 800 lb. The real origin of the Dexter is not known, but it is believed to be the result of breeding from specially selected Kerries. Mr. Hordern, secretary of the English Kerry and Dexter Society, estimated the average yield of both Kerry and Dexter cows at 2¾ gallons a day for heifers and 3¾ gallons for cows, but we must regard these figures as applying to selected stock only.

The cow La Mancha Beatrice, having calved in July, gave 4 gallons daily in October, this containing 4 per cent. of fat; Red Rose gave between December and September, 1,270 gallons of milk; and Mr. Robertson's Edna, 6 years old, 41 lb. 14 oz. in the Derby competition.

Management of the Cow. The student will find our general remarks on the Breeding and Management of Cattle on pages 2238–40. We have therefore confined ourselves to the special treatment to be pursued in connection with the milking breeds.

When a cow has been purchased she is in practical dairying, usually in milk or in calf, or both. If she be dry and pregnant, it should be possible to recognise the presence of the calf by pressing with the back of the index finger and the ball of the thumb rather low down in the abdomen below the hips on the right side. The fact of a cow being dry is presumptive evidence that she has been dried for calving, but the calf may be felt before drying off by an expert as early as the fifth and sixth month after service. A cow in season indicates the fact by her excitability, and by other signs which every stockman understands. The skilled are aware what course to pursue, but in the case of the unskilled we strongly urge that when it is intended to breed from a cow thought should be given to the matter before deciding by what bull she should be crossed. It is far more economical to employ a suitable bull of a deep milking strain, and to pay a guinea for service, than to use a nondescript bull without any payment whatever. In the ordinary way, a milking cow should be dried six weeks before she is due to calve. In drying a cow, the milker commences by omitting a daily milking for a few days, and then by omitting to milk altogether. Some cows continue, in spite of all precautions, to milk right up to calving, with the result that the fœtus is starved, and on its appearance is usually weak, fragile, and undersized. A week or two before calving—or when, owing to her breed or history, milk fever is anticipated—a cow of a fleshy breed should be scantily fed that her condition may be reduced. If she be turned out, a poor pasture will serve the purpose best, without any addition to her ration. If she is being stall-fed, cake and meal should be omitted, a light ration of hay alone being provided, and she should have plenty of exercise.

Calving. When calving is near the cow should be watched and kept untied night and day, either on a pasture or in a loose-box. Some farmers would milk her every night to prevent her calving before the morning, but this plan is not infallible. Sometimes, after calving, the "placenta," or after-birth, refuses to pass. This is a troublesome and sometimes dangerous affair. A drink may be obtained to help the animal, while to the exposed portion of the "cleansing" a thin cord should be attached with a light weight at the end that there may be gentle and continuous force exerted which will induce it to disattach itself. During the retention of the placenta, and to prevent poisoning by its decomposition within the animal's body, the passage should be daily disinfected with carbolic acid at the rate of 1 part to 50 of water. In some cases, where the attachment is slight, the after-birth may be gently removed, or torn away by the hand. Cleanliness, at all times important, is doubly so at this period. In all cases the after-birth should be buried.

It sometimes happens that after calving one of the teats of the udder is blocked, and refuses to pass milk. This is sometimes owing to a chill, sometimes to the carelessness of a milker before calving. It will need careful and gentle manipulation, and it may be necessary to strip it, or attempt to strip it, every couple of hours through the day in the effort to remove the material or cause of stoppage. The loss of a teat is serious, for if it does not actually involve the loss of a full quarter of the milk which the cow should give, it diminishes her saleable value. Should hand manipulation fail, the calf should be tried. In the ordinary way, a calf will succeed where man does not, suction being powerfully brought to bear. Should there be no good result from either course, a silver tube must be obtained, and after lubricating with oil, very carefully introduced into the duct of the teat. This will usually pass sufficiently far to enable the milk to flow, but the passage may close again unless the greatest possible care be exercised. Another trouble is the hardness of the udder, which may arise from one of various causes. Here, too, the calf's assistance is often important, and although it is the practice of many breeders to remove the calf at birth, and to feed it from the pail, it had better be left with its dam in such a case, that by its repeated sucking and punching, the udder may return to its normal condition. Failing the calf, hand rubbing with oil or goose grease is often found effectual, but in all cases the udder should be stripped of its milk every three or four hours.

Colostrum. The first milk drawn from a newly-calved cow is of much deeper colour than normal milk. It is known as *colostrum*, and is unquestionably valuable for the calf, upon which it acts medicinally. Colostrum is extremely rich in solid matter, especially casein and albumin. The solids may reach 25 to 28 per cent. against 13 in normal milk, while the casein and albumin may reach 15 to 20 per cent., against 4 per cent. in average milk.

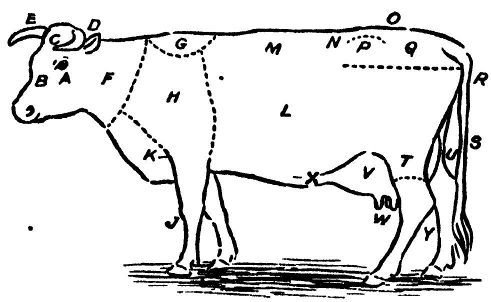
Abortion, or slipping of the calf, is one of the accidents and misfortunes of the dairy herd. A cow purchased in the market or elsewhere may be infected, and if the fact be unknown, may remain with the herd in her new home, and infect the cows around her [see page 2623]. No trouble should be regarded as too great in a case of this kind, for abortion in the herd has often ruined a farmer. A cow which has aborted should be fed for the butcher, as there is some risk of infecting the bull, and through him the whole herd.

Breeding. Where a farmer breeds his own stock, he must decide at what age and under what conditions his heifers should be mated. A heifer which is undersized, raw, and still growing, had better wait until from 19 to 21 months, but large-framed beasts, which are practically mature enough for breeding, may undoubtedly be introduced to the bull at 18 months. A heifer should never be retained for breeding if she be unhealthy, or, indeed, if she be not robust. It is far wiser to feed her for the butcher. Much is accomplished by good feeding from birth, maturity is hastened, strength is imparted, and an animal may be brought into the dairy as a profitable servant at the age of 2¼ years instead of 2½ years or later. There are too many who fail to feed well, and who allow their young

stock to graze upon poor pastures in the belief that they are saving money by the practice. Ungenerous feeding is, however, uneconomical. In the case of the males of a herd, a young bull may prove unfertile from time to time owing to the scanty way in which he has been fed.

In the vast majority of cases cows calve in spring, but the farmer is able to control the period of calving in accordance with the value of the calf or of the milk. The cheesemaker requiring milk from April to September prefers the spring calving cow; the milk seller, who caters for winter prices, often prefers the autumn calver, that he may obtain a larger yield at a time when it returns him the most money. It is important, therefore, that where cows are to calve at given periods, the bull should be confined to a box and yard, and only used when the cows are in season and at the right date. Where the cows calve in spring labour is reduced together with the cost of feeding, for the herd, being on the pastures, are pretty much left to themselves. In winter, however, the milking cow is stall-fed, and this not only involves greater cost, but demands greater attention at the hands of both owner and men. As we shall see, however, some hand-feeding in summer is important, and, indeed, imperative.

Points a Purchaser Must Look for. It is important in purchasing a cow that no mistake should be made as to her value. There is no lesson in this matter which can compare with experience, but a few words will help even the experienced buyer. The animal [6] should be large for her breed, with a capacious belly, breadth across the hips, a straight back, depth of loin, width between the buttocks, fine shoulders and neck, a long, fine head, powerful muzzle, and fine shapely horns characteristic of her breed. A short, thick cow with a deep brisket, coarse head and neck, heavy shoulders, and great fleshy character should be rejected, especially if the udder be small and narrow. She should be healthy, quiet, gentle, chewing her cud when at rest—a very good sign of health; her horns clean and without many wrinkles, her teeth sound (both teeth and wrinkles on the horn indicate age), and provided with a well-formed large udder with a silky covering much shrunken after milking. The size of the udder is not an absolute guide to milking power, and therefore in purchasing from a private buyer on the farm it is wise to see selected cows milked morning and night, and to take the precaution not to inform the seller when a visit for the purpose will be made, or the animals may possibly be "stocked" for the purpose—*i.e.*, unmilked at the previous milking time. A good cow milks well to the last; nevertheless, a very heavy yield with one calf may be followed by a much lighter yield with the next, although later the return is almost certain to be good. There is no empirical method of selecting a good milker. The best judges are often deceived by appearances. A healthy cow has warm ears, a loose, mellow skin, horns warm at the base, and dew on her nose. Details as to teeth, with two diagrams, are to be found on page 2239. It should be noted that a cow always grazing pushes her teeth through more rapidly, whereas fed in the stall she has less use for her incisors, which may in consequence appear later.



6. THE POINTS OF THE COW

a. Eye *b* Face *c.* Forehead *d.* Ear *e.* Horn *f.* Neck *g.* Top of shoulder *h.* Shoulder *j.* Knee *k* Dewlap *l.* Ribs *m.* Back *n.* Loin *o.* Rump *p.* Hip *q.* Quarters *r.* Tail *s.* Switch *t.* Thigh *u.* Hock *v.* Udder *w.* Teats *x.* Abdomen and milk vein *y.* Hock

Care of Stock. Although the practice is most uncommon, cows should be daily groomed, scraped in winter, and washed, if necessary, to keep the flanks and buttocks clean. The average cow in winter is plastered with the manure on which she lies; this dries and cakes, and disfigures her, until she loses her coat, apart from which the practice is filthy, and contributes to the contamination of the milk. A cow which is never cleaned may be attacked by ringworm, and is almost invariably covered with parasites; her coat is the abode of dirt, and the milk she yields is daily tainted in consequence. Apart from grooming, the coat should be washed at least once a week with soap and water, to which a small quantity of carbolic acid has been added. One part in fifty will destroy parasitic life. Should ringworm appear in cow or calf, immediate and persevering attention should be given, few complaints being more obstinate. The edges of the crust of the growth may be removed a little at a time, and the whole daily rubbed with carbolic or mercurial ointment, which, however, fails to penetrate the crust itself.

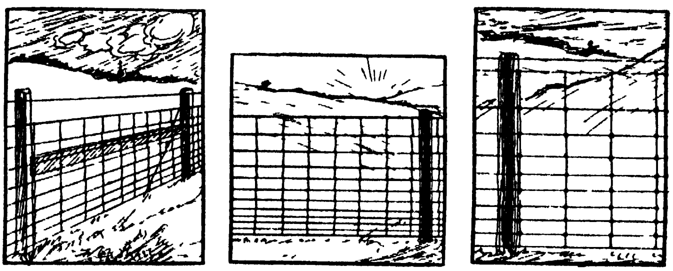
The Byre. The buildings in which cows are stalled, milked, and fed vary in design. They have been described on page 2997.

The cows may be tied to the stalls in one of many ways. A common plan is to affix a vertical iron rod right and left with screws at each end to each partition. A chain is attached to this rod by a ring that it may slide from top to bottom, and thus each cow is fastened when the chain is passed around her neck to the partition next to which she stands, and is able to feed from the manger without too close contact with her neighbour. Food receptacles, however, whether manger or rack, are provided in numerous forms, and the remark equally applies to the various methods of changing the cows, especially in the United States, where they are in many cases most ingenious. An advantage of the firebrick manger is that if a tap be fixed at one end, and a pipe and plug at the other, the whole

may be flushed out with water and cleaned, while, when necessary, it may be partially filled with water for the cows to drink. The walls of the cowhouse should be periodically lime-washed, and the floors disinfected daily; where the latter are made of burnt clay or firebrick, and grouted in cement, they should also be flushed with water. In winter the stalls may be littered with straw—oat straw is best, especially as a portion will be consumed by the cattle—with peat moss, or even with sawdust or shavings, if other materials be not obtainable, although the latter do not make the best or most desirable of beds.

It is essential that boxes should be provided for calving cows, calves, and sick cattle, all of which should be well lighted and ventilated, but kept free from draughts.

Storing and Preparing Cattle Fodder. A food store and mixing apartment where a number of cows are kept is required, and it is a good plan to construct this in the centre of the cattle building. The floor should be of concrete, and arranged so that the pulped roots, the chaff, the cake, and the meal or grains used may be close at hand ready for mixing in a heap morning and night. The mixture is usually allowed to remain heaped for twelve hours that it may ferment. Being thus warmed, it is either carried in tubs or baskets, a galvanised iron barrow, or a tramcar, direct to the cattle.



American   Peerless   Advance

7. TYPICAL MODERN FENCES

Where many cows are kept the small steam or oil engine described on page 2999 may be used with advantage. There should be a loft or store overhead, and here the chaff-cutter may be fixed, the hay or straw being delivered from the outside of the building and the chaff as it is needed passed below through a trap-door in the floor. A belt attached to the shafting which drives the chaff-cutter will serve to drive the pulper and the corn mill; hence if a store for roots be conveniently placed into which they may be delivered by the carts from the field, and if the grain to be ground be stored in the loft, the food may be conveniently prepared and mixed as occasion requires.

When and How to Milk. Cows should be regularly milked, whatever the hours fixed may be; but it has been shown by experiment by milking at three periods—6.30 a.m. and 2.30 p.m., 6.30 a.m. and 4.30 p.m., and 6.30 a.m. and 6.30 p.m.—that although the yield was practically the same in each case, the mixture was richer when drawn at the first two periods. Except when milked twelve hours apart, or thereabouts, the milk of the evening is always richer than that of the morning. Milkers should be encouraged to milk with dry hands, otherwise the practice of dipping the fingers into the pail is regularly followed. The practice is not only disgusting, but contributes to the non-keeping power of the milk, which is thus contaminated. Cows may be trained to be milked in the fields—as in Holland, where they are frequently tied to posts, or in Normandy, where they stand quietly for the purpose. In each case the necessity for bringing the milk home is involved. The Dutchman brings it in his boat, the Norman dairymaid on her head, or in the panniers on the back of an ass.

When the milkers enter the cowhouse early on the winter's morning, the cows may be supplied with a little sweet hay or, if the owner prefers, with their morning's mixed ration. The udders are then cleansed, the milkers wash their hands, don their overalls, and draw the milk in pails which have been cleansed overnight and left in the air. After milking, and when the food has been consumed, the cows may be turned out either to graze and drink, or, when the weather is severe, for exercise and drink. After breakfast the men proceed to clean out the stalls, gutters, and houses, and then to prepare the ration for the following day. In summer the cows remain in the fields, but attention should be given to gates, fences [7], the water supply in ponds or streams, to possible gaps in hedges, and, where forage crops, such as vetches, rye grass, trifolium, clover, lucerne, cabbage, or maize are provided, to the cutting of the food and its conveyance either to the pastures where the cows are grazing, or to the mangers. It will usually be found essential to allow the forage mown in the morning to remain until the next day before it is supplied, that it may lose part of its moisture, otherwise hoven [see page 2623] may follow, especially when this form of feeding is commenced and when the food is young and succulent.

Necessity for Keeping Records. The system of recording the milk yield of each cow should be followed on every farm. There is no other method of ascertaining her intrinsic milk value. As the milk is drawn from each animal the pail should be placed upon a scale, the net weight ascertained, and marked on the record sheet on the wall. A glance at such a sheet daily will suffice to satisfy an owner, or to indicate when the yield suddenly falls off in a particular case, whether the cow be in season or suffering. The practice of measuring is misleading, and should never be followed; weight is the only certain factor, and, roughly, a gallon may be estimated as weighing 10 lb.

Continued

66. ST. PETER'S, ROME

Alinari

RENAISSANCE ART

Architecture and Sculpture of the Renaissance. The Work of Michelangelo, Donatello, Ghiberti, and Della Robbia. Other Great Renaissance Masters

continued from page 3529

By P. G. KONODY

THE history of the early Renaissance is inseparably connected with the history of Florentine art. It is, indeed, difficult to follow the evolution of the revival in the three sister arts separately, since the giant minds of that period did not restrict their colossal activity to a single sphere, and mastered the terms of many arts. We have already seen how Giotto achieved greatness in painting, sculpture, and architecture. Others there were in the fifteenth and sixteenth centuries who were goldsmiths and sculptors and painters; there was no art that Michelangelo did not master, and Leonardo da Vinci combined the functions of military engineer, musician, poet, writer of scientific treatises, and stage manager of glorious spectacles with those of painter, sculptor, and architect. There was a constant interchange of ideas, and each art left its mark on the sister arts; each step forward in the one was reflected by the others.

The Renaissance House. In architecture, the ideal form of the private dwelling was the greatest achievement of the Renaissance, and of Filippo Brunelleschi (1377 to 1466) its creator. The Gothic house was a kind of miniature fortress, with a narrow, high street front, as few apertures as possible, and narrow, irregular passages, rooms, and winding stairs. With the growing wealth and luxury of Florence, and increased security of life, a new type of building had to be evolved, a palace that should express the new conditions, the wealth and power and taste of the merchant princes who ruled the city. Spaciousness, comfort, air and light were the primary considerations which led to the adoption of a wide street front, clearly articulated but not over-decorated, a spacious ground plan with only few storeys and suites of large well-lighted rooms. The beauty of the façade is based on noble proportions, on the relation of the massive "rustica" masonry—composed of rough-hewn blocks finished off only at the joints—to the window openings, which are generally divided by columns or mullions, and the classic cornice or attic.

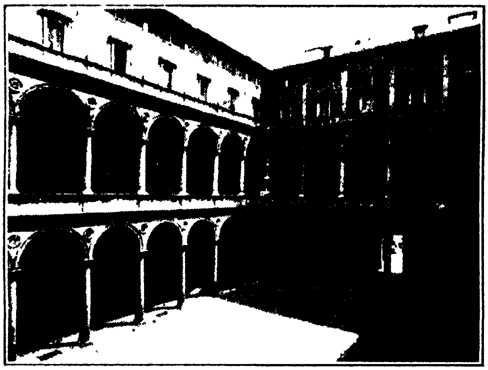
The most striking feature of the Florentine palace is the handsome inner court surrounded by slender colonnades, which are sometimes arranged in two tiers. The charm of the façade lies in the play of light and shade of the strong southern sun on the roughly hewn masonry, the arches and pilasters of the windows, and the boldly jutting cornice. Brunelleschi's Pitti Palace [70], Michelozzo's Riccardi Palace, and the wonderfully impressive Palazzo Strozzi [68], the plan of which is, with little show of reason, attributed to the sculptor Benedetto da Majano, are the noblest instances of the Renaissance Palace, not only in Florence, but in the whole world. In Venice, the Palazzo Vendramin, graceful in form and resplendent in coloured marble casing, shows the adaptation of Venetian decorative devices to the style born in Florence; whilst, if we turn from secular to ecclesiastic architecture, in the façade of the Certosa di Pavia, begun in 1473 by Ambrogio Borgognone, with its wealth of marble incrustation, reliefs, niches, statues and medallions, the dignity of the style has given way to playful exuberance.

Churches. The great Cathedral of Florence, which had undergone many modifications in the two centuries of its building, received its imposing cupola by Brunelleschi, who thus solved a problem which had baulked the efforts of all his predecessors; but in spite of this dome it remains in its essential features a Gothic building. The churches of S. Lorenzo and S. Spirito, and the graceful Pazzi Chapel, are the three most important Renaissance churches built by this master. Alberti, the designer of the façade of S. Maria Novella, in Florence, and the inventor of the volutes masking on the exterior the junction of the nave and the lower aisles, went further than Brunelleschi in his adherence to the classic orders; he lacked the other master's inventive genius and sense of elegant proportions, and tried to make all architectural forms fit in with his favourite theories.

In the sixteenth century the powerful and liberal patronage of the Popes attracted the leading artists of the whole of Italy, and made Rome the centre of artistic activity. Here, on classic soil, architects were enabled to study the ruins of antiquity and to formulate their knowledge into a scientific system. True enough, the classic forms continued to be a mere outer garment which clothed the buildings that were adapted to modern requirements, but they were applied with better understanding of their functions, with increased sureness and purity. In the palaces the storeys were clearly divided by cornices, the windows framed by pilasters and surmounted by triangular or curved pediments of purely classic proportion. As regards the use of the "orders," the superimposed storeys led the eye from the heavier Doric, through the Ionic, to the graceful Corinthian. In church architecture the mighty dome, in conjunction with a barrel-vaulted nave, became the firmly established type of the later Renaissance.

Masters of the Renaissance. Bramante, who has left much of his early work in and around Milan, played in Rome the same

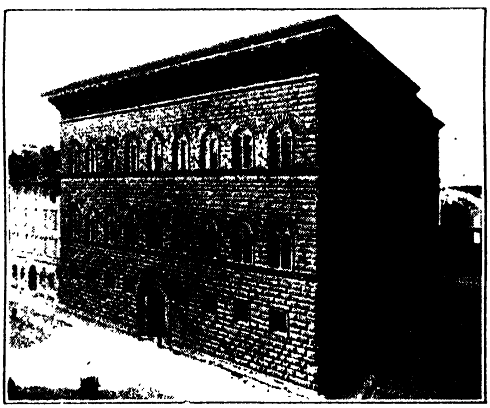
part that Brunelleschi had played in Florence. He is the initiator of the second period, the first of the many builders who helped in the erection of St. Peter's, and the architect of the beautiful Cancelleria [67] and Giraud Palaces. The great Raphael's chief building is the Palazzo Pandolfini, in Florence, where the alternating triangular and semicircular pediments over the windows are introduced for the first time. Antonio da Sangallo, the builder of the Farnese Palace in Rome; Baldassare Peruzzi, the scene of whose captivity was Siena; Giulio Romano, who worked in Mantua; Sansovino, the designer of the library of S. Marco and of the Zecca, or Mint, in Venice, are among the leading masters of the late Renaissance which culminated in the work of Michelangelo. In his striving for a grand general effect, without much concern with detail, he introduced the germ of the lawlessness which set in after his death and led to the exaggerated forms of the Baroque style. The gigantic cupola of St. Peter's in Rome [66], and the Medici Chapel in Florence are his most famous architectural works.


Alinari

67. THE CANCELLERIA PALACE, ROME

Sculpture. In sculpture, as in architecture, Florence was the centre of the early Renaissance, but chronologically a Sienese master, Jacopo della Quercia, stands between the Gothic Orcagna and the first great sculptor of the new epoch, Ghiberti. Though in many ways still addicted to Gothic mannerisms, Jacopo is, in his boldness of vision and vigorous treatment of the human form, a true child of the Renaissance, and stands nearer to Michelangelo than any of the intervening Florentines. Ghiberti's greatest work is the gates of the Baptistery in Florence [69*E*], of which Michelangelo said that they were worthy to be the gates of Paradise. In comparing them with Andrea Pisano's, one is immediately struck by the inimitable sense of beauty that pervades the later artist's work; the exquisite finish which betrays the goldsmith's training; the wonderful grouping of the figures in receding planes, and the corresponding variations in the relief treatment, from the foreground figures, which stand forth in their full roundness, to those in the far background, which are indicated by scarcely more than a few lines. In fact, Ghiberti was the first sculptor who made use of linear perspective in relief work, and his work is almost pictorial in character.

Greatest Sculptor of the Renaissance. Donatello is acknowledged to be the greatest, as he was the most productive, sculptor of the Renaissance. He lacked, perhaps, the pure sense of beauty of Ghiberti, but there is in his work something greater than formal beauty — the beauty of character, which renders the very harshness fascinating. Everything he wrought, in marble or in bronze, is full of expression and life, character and movement. [See **29**, page 1511.] And his leaning towards extreme realism was tempered by his knowledge and love of the antique. He worked from the living model, but had before his mind's eye the masterpieces of classic art. This is especially apparent in his bronze "David" at the Bargello, in Florence [69*A*], the first nude bronze of modern times. There is nothing less than classic beauty in the graceful, well-balanced attitude and the well-shaped legs, whilst the thin, angular arms are copied from the living model. And yet the figure is quite homogeneous; it has the thrill of life, and in its very deviations from the classic ideal conveys the idea of the immature shepherd youth and giant-killer. And Donatello approached every successsive task in the same objective spirit, dealt with each on its own merits, infused pulsing, throbbing life into cold stone or bronze. His "Gattamelata," in Padua [69*B*], is the first equestrian statue since classic times, and has never been surpassed in impressiveness and dignity save by Verrocchio's "Colleoni" [**31**, page 1674] in Venice. [See **69***F*.]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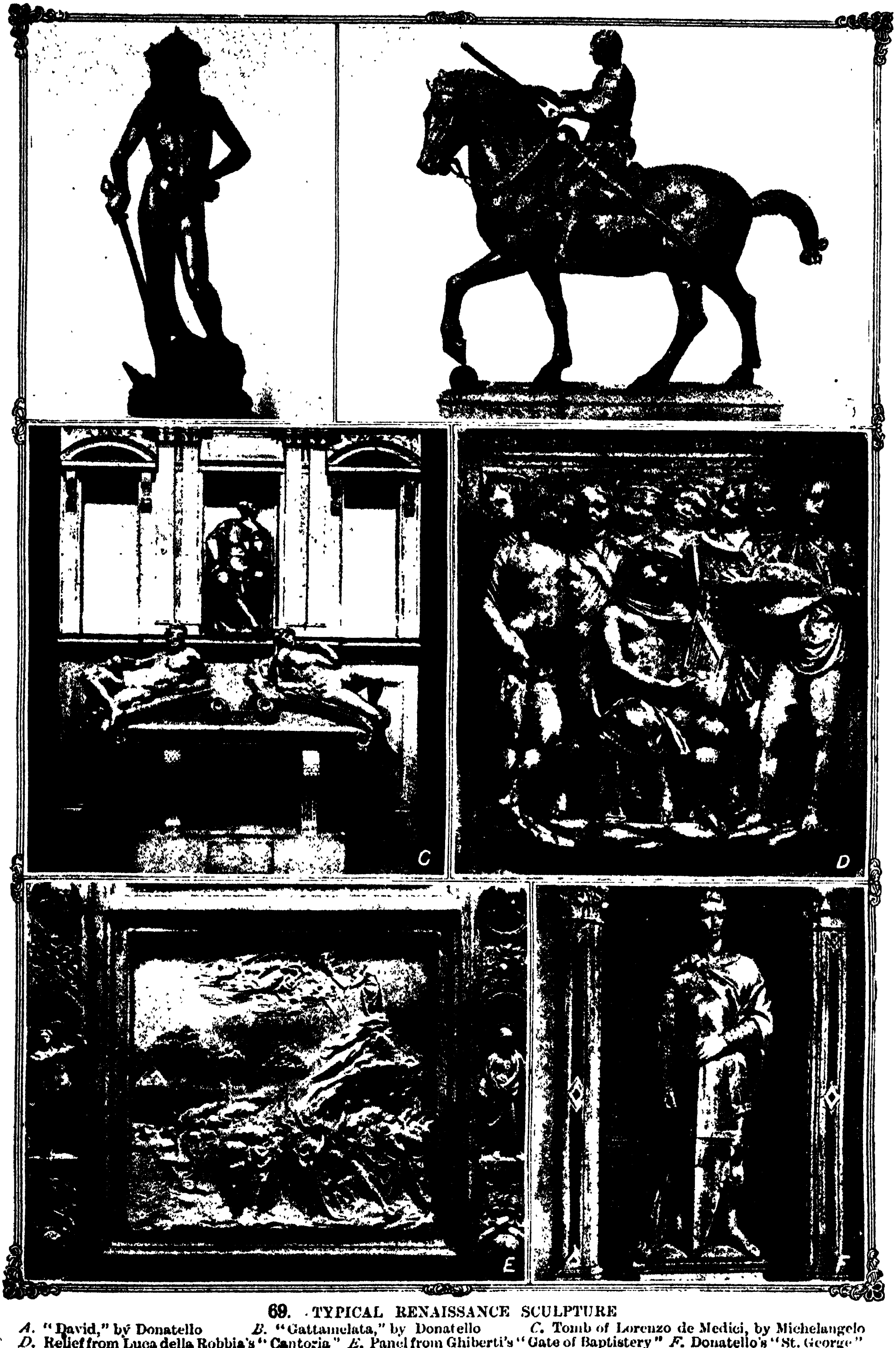
68. THE STROZZI PALACE, FLORENCE

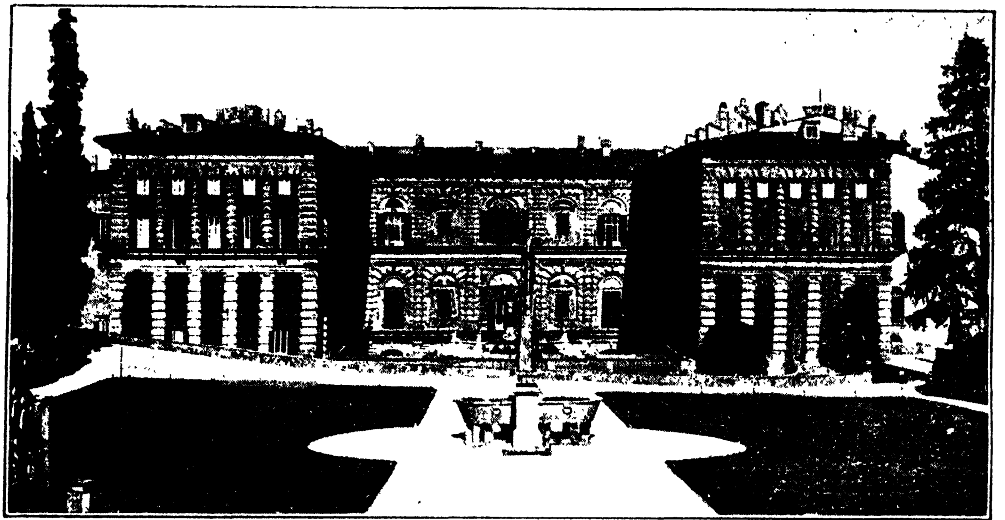
The third great master sculptor of the early Renaissance was Luca della Robbia, the founder of a whole dynasty of workers in glazed terra-cotta, and at the same time one of the leading sculptors in marble. Of all the early Renaissance sculptors, Luca was the one that came nearest to the Greek spirit of calm serenity, though in subject matter he was further from the antique than any of his contemporaries. Motherly love and tenderness



69. TYPICAL RENAISSANCE SCULPTURE

A. "David," by Donatello *B.* "Gattamelata," by Donatello *C.* Tomb of Lorenzo de Medici, by Michelangelo *D.* Relief from Luca della Robbia's "Cantoria" *E.* Panel from Ghiberti's "Gate of Baptistery" *F.* Donatello's "St. George"

Photos by (A) Alinari, (B, C, D and F) Anderson, (E) Brogi



70. THE PITTI PALACE, FLORENCE *Alinari*

and happiness were his favourite themes, and have perhaps never found more beautiful expression in plastic art. Of his marble works the most famous is the singing gallery, in Florence [**69***D*].

Donatello was followed by a whole school of great marble workers who devoted themselves chiefly to tomb monuments and portraiture. The tomb of the period was generally conceived in the form of a recumbent figure of the dead on a sarcophagus in a niche, the architectural setting being in perfect harmony with the purely sculptured part, and richly decorated. Desiderio da Settignano, Mino da Fiesole, Rossellino, Benedetto da Majano, and Pollajuolo must be mentioned among the leading masters of the fifteenth century. Verrocchio, who excelled in bronze work, and is the creator of the world's greatest equestrian statue—the Colleoni monument in Venice—has left comparatively few works, but exercised an enormous influence as a teacher. Leonardo de Vinci was one of his pupils, and the first suggestion of the enigmatic type of face, which is always associated with Leonardo's work, can be found in Verrocchio's bronze " David " at the Bargello, in Florence.

Michelangelo. Sixteenth century sculpture is overtowered by the mighty genius of Michelangelo, whose work is the embodiment of the highest ideals of the late Renaissance. To the close of his earlier period belongs his colossal " David," that wonderful figure of a youthful well-proportioned giant, which the master chiselled out of a spoilt block of marble.

In his later work Michelangelo to a certain extent broke away from the Greek ideal, as he had broken away from everything that had gone before him, to find an adequate expression for his passionate spirit. As a poet for the sake of emphasis is allowed to change the natural proportion of speech, so Michelangelo in sculpture departed from strict truth to nature, exaggerating certain actions or muscles or limbs, for the sake of accent and increased impressiveness. At the same time he knew, like no other master, how to vary the texture of the surface to secure the desired effects of light and shade. The tombs of Lorenzo [**69***C*] and Giuliano de Medici, with the attendant figures of " Night and Day," " Dawn and Twilight," mark the height of his achievement.

Between the early Renaissance and Michelangelo stands Andrea Sansovino, the creator of the Cardinal Sforza tomb at S. Maria del Popolo, in Rome, a monument which shows Andrea's complete mastery of classic forms, though the sarcophagus with the recumbent figure is overwhelmed by the architectural setting and subsidiary figures. His pupil, Jacopo Sansovino, has left many beautiful works in Venice. Of the other masters of the period only Giovanni da Bologna and Benvenuto Cellini did not succumb to the influence of Michelangelo, which proved baneful to all others who succeeded him, and contented themselves with turning his style into mannerism by absurd exaggeration of distorted proportions. Baccio Bandinelli is the typical sculptor of this period of decline.

Giovanni da Bologna's bronze " Mercury," with its fine expression of swift upward movement and its brilliant adaptation of the modelling to the material, is the work by which this master will be best remembered, whilst Benvenuto Cellini, the sculptor goldsmith, whose chief fault was that he treated monumental sculpture in the spirit of the goldsmith, and his goldsmith work in that of the sculptor, has left the world the famous " Perseus " in the Loggia de' Lanzi, in Florence.

A special branch of sculpture, which reached its highest development in the early days of the Renaissance, is the art of the medallist. Vittore Pisano, who flourished in Northern Italy in the early fifteenth century, was the first great medallist, and remained unsurpassed.

Continued

FOREIGN BILLS AND EXCHANGES

Group 7
CLERKSHIP
26

Continued from page 3571

Consignments Inward and Outward. Mutual Indebtedness of Countries. Par and Course of Exchange. Gold Movements. Bill Market

By J. F. G. PRICE

IT is now more than three years since the attention of the people in the United Kingdom was particularly drawn to the whole question of our trade with foreign countries. This is not the place in which to enter into a discussion of the merits of the two fiscal systems which for some time were argued by leading men on both sides, but if the raising of the subject has had the effect of making our manufacturers and merchants alive to some of the defects in their methods of conducting their foreign trade a great deal will have been accomplished.

Imports and Exports. The importance of the subject is not likely to be underestimated, but it may be mentioned that in 1905 our foreign trade amounted to £973,000,000, of which £565,000,000 represented imports and £408,000,000 exports. The difference in value between the imports and exports is known as the balance of trade, and it was formerly held that in order that a country should be in a prosperous condition the exports should always exceed the imports. This idea no longer holds the field in its original shape, attention being now directed more to the nature of the articles making up the total than to the totals themselves—*i.e.*, whether they consist of raw or manufactured goods. Considerations of space forbid a lengthy explanation of the methods of conducting the foreign trade of the country generally, and our purpose here is to deal with the matter from the view of accounts.

There are three principal methods of selling goods—*viz.*, direct, at auction, and on commission. The method with which we shall now deal is the one last mentioned, since the first has already been the subject of our various examples hitherto, and the second is really covered by the others. Most of the goods exported by our merchants are in execution of orders received from abroad—*i.e.*, they are sold before they leave this country; but other transactions are entered into where no sale has taken place before the goods are exported, and where the object in sending them is to endeavour to find a buyer in the place to which they are sent. The goods are despatched to an agent in the town or country in which the merchant hopes to find a market for them, arrangements having first been made with the agent as to the terms upon which he will act. These terms are generally reimbursement of his out-of-pocket expenses, and a commission by way of a percentage upon the selling price of the goods.

Consignments Outward. The goods sent out by a merchant in this manner are termed in his books a *consignment outward*, while the same goods are referred to in the books of the agent who receives them as a *consignment inward*. The merchant, who is known as the *consignor*, keeps an account in his books of the cost of the consignment, both as regards the price of the goods and the expenses incurred. He does this because he desires to know the outcome of each consignment, whether it results in a profit or a loss, so that he can form an opinion whether it would be advisable to send further consignments to the same place or to the same agent. When a large consignment business is done a special book is kept in which to record all goods sent out in this way. The book is treated in the same manner as a sales book, the entries in it being posted periodically to the ledger. When there is only an occasional transaction of the kind the entry can be passed through the journal, debiting the consignment account and crediting goods account.

Consignment Accounts. A ledger account is required for each consignment, to record the separate results as well as the net result of the whole. The consignments are, therefore, numbered or given distinguishing titles according to either the place to which they are sent or the consignee's name. If accounts of consignments outward are distinguished by the names of the consignees it must be borne in mind that they are merely subsidiary goods accounts and not personal accounts upon which the consignees are liable. The first entry on the account is on the debit side, and consists of the price of the goods. As payments are made in connection with the consignment, the account is debited and cash credited. Any liability incurred in connection with it is debited to the account and credited to the person or firm to whom the amount of the liability is due.

A *pro forma* invoice is made out and sent to the agent, with instructions as to the minimum price at which he is to sell. If he is successful in his efforts and disposes of the consignment, he prepares and forwards to the consignor a statement called an *Account Sales*. This shows the gross amount realised, details of his expenses and commission, and the net amount due to the consignor. This amount he remits to him in the manner dealt with later.

The consignor enters the amount of the net proceeds as shown by the account sales on the credit side of the consignment account, the balance on which will then represent his profit or loss on the venture. The reason for this is that the total cost, both in goods and expenses, will appear on the debit side, and the net amount realised on the other. The difference is, naturally, the gain or loss.

The consignee terms the goods a *consignment inward*. If he acts as agent for a number of merchants, or has many consignments from one merchant, he keeps a special book in which he records particulars of all goods so received. This record will usually be merely a memorandum, and no entry will be made in a book of account upon the receipt of the consignment. The reason for this is that the goods do not, on the one hand, belong to the consignee, and therefore cannot be debited to the goods account; while, on the other, the consignor is not his creditor for the value of the goods, since the consignee has not bought them and is not liable for the price. He is only responsible for their safe custody and for the proceeds if he effects a sale. If he is not successful in this he can return the goods. As a rule, then, no account is opened by a consignee when he receives goods on consignment, but as soon as he pays anything or incurs any liability in respect of it he records the fact in his account books. He does this by opening an account in his ledger in the name of the consignor (not a consignment account, but a personal account), and debits the amount paid or the liability incurred. The reason for this is that the amount is due from a definite person, and he naturally debits that person and not an impersonal account. At the same time, he credits cash or the person to whom the amount is due.

When a sale is effected the consignee debits the person to whom the goods have been sold and credits the consignor, because the amount then becomes due to the latter, subject to the payments or charges which may have been made on his account. The consignee then calculates his commission and debits the amount to the consignor, who, of course, is liable to pay it. The balance on the consignor's account will then represent the amount due to him, since he has been debited on one side with all payments made or expenses incurred on his behalf and with the agreed commission, while he has been credited, on the other side, with the gross proceeds of the goods. The consignee then remits the balance due, usually by a bill of exchange, and the method by which he does so is explained later. When the purchaser of the goods pays for them, cash is, of course, debited and the payer credited. This will close the transaction in the consignee's books.

For the purpose of making the course and result of the operations clear to the mind of the student, a series of transactions will be dealt with and the ledger accounts shown in the books of both the consignor and the consignee. W. Brown, of London, ships to J. Bonhomme, of Bordeaux, ten bales of 400 yards each of cotton goods at 8d. per yd. and pays £15 for freight, £2 13s. 4d. for insurance, and £6 5s. 3d. for cartage and miscellaneous charges. Bonhomme receives the goods, and pays £3 for storage, £1 for insurance, £10 for Customs duties and landing charges, and £3 for miscellaneous expenses. He sells four bales at 1s. per yd., and the other six at 1s. 0½d. per yd. His commission is 2½ per cent. on the proceeds. Bonhomme's payments and transactions, taking place in Bordeaux, will naturally be in French currency, but for the sake of simplicity they are given in the accounts in sterling.

They are, however, for the guidance of the student shown in the account sales on the next page in French currency just as they would appear in the statement as rendered by Bonhomme. It will be observed that the balance shown by account sales to be due to W. Brown is stated therein both in French currency and in its British equivalent.

The following would be the accounts in the two ledgers:

W. BROWN'S LEDGER

Dr. Consignment to J. Bonhomme, Bordeaux **Cr.**

		£	s.	d.			£	s.	d.
1905 July 1	To Goods	133	6	8	Sept. 6	By Bill receivable for net proceeds as per Account Sales	182	17	6
,, 2	,, Cash, Cartage, etc. ..	6	5	3					
	,, ,, Insurance ..	2	13	4					
	,, ,, Freight	15	0	0					
Sept. 30	,, Net Profit transferred to Profit and Loss Account	25	12	3					
		£182	17	6			£182	17	6

J. BONHOMME'S LEDGER

Dr. A/c of W. Brown **Cr.**

		£	s.	d.			£	s.	d.
1905 July 9	To Cash, Duties & Landing	10	0	0	July 31	By F. Martini, 4 bales @ 1s.	80	0	0
	,, ,, Storage	3	0	0	Aug. 31	,, ,, 6 bales @ 1s. 0½d.	125	0	0
	,, ,, Insurance ..	1	0	0					
	,, ,, Miscellaneous ..	3	0	0					
	,, Commission % ..	5	2	6					
	,, Bill payable for balance as per Account Sales	182	17	6					
		£205	0	0			£205	0	0

Foreign Exchanges. The words relating to the payment of the balance due to the consignor, as shown on the account sales, brings us to the general question of the foreign exchanges. The consignee, being a Frenchman, naturally keeps his books in the currency of his own country, and renders accounts to his English consignor in the same way, merely remitting the ultimate balance due in English money. We have now to inquire how he does this, and how he arrives at £182 17s. 6d. as being a fair equivalent of 4,608 fr. 45 c. He could, no doubt, have purchased English gold and silver coins to the amount he has to remit, but obviously this would be a clumsy and costly method of discharging the liability, and is no more adopted in practice between foreign countries and England than it is between two towns in the same country.

The remittance, as stated in the account sales, is made by a bill of exchange, and the bill is obtained by the consignee finding somebody in Bordeaux who has a debt due to him from a person in England and purchasing the right to receive payment of such debt. Let us take a simple illustration to see how this is brought about, and how the indebtedness of two persons to two others, on perhaps many transactions, can be settled by one payment. A in Bordeaux buys goods from B in London, while C in London buys goods from D in Bordeaux. We will assume that the amount is the same in both cases. D draws a bill upon C for the amount the latter owes him. A becomes aware of this and buys the bill from D for its fair equivalent in French money. Having obtained the bill he sends it to B in London, who presents it to C, and in due course receives payment from him.

Par of Exchange. We now come to the question of what is a fair amount in French money to pay for a given amount of English money. To obtain the answer we must know the state of the currency of each country, what is its standard coin and of what metal it is composed. In England, of course, the standard coin is the gold sovereign. It contains a certain quantity of alloy for hardening purposes, the proportion of pure gold in the sovereign being eleven parts in twelve. In France the standard coin is the franc, but as this is a silver coin the value of French money as compared with English is measured by the 20-franc piece, which is of gold. The fineness of this coin—*i.e.*, the proportion of pure gold in it, is nine parts out of ten. There is thus a small difference in favour of the English currency in the proportion of pure gold in the coins of the two countries; and although it is trifling in one coin it becomes of great importance when large amounts are involved, and has to be taken into account when stating the quantity of French coins which are required to make up the value of the English sovereign.

A further point which has to be taken into consideration in fixing the relative values is the difference in the weight of the sovereign and of the 20-franc piece. The sovereign weighs 123·27 gr., the 20-franc piece 99·56 gr. Obviously, then, we shall require more than 20 francs for one sovereign, and after taking both weight and fineness into consideration, it is found that the English pound is equal to 25·2215 francs, or, roughly, 25 fr. 22 c. This is known as the *par of exchange* between France and England, and is the basis upon which settlements of account between the two countries take place.

But although it is the basis, there are many considerations which help to raise or lower the rate. Owing to the very considerable trade between England and France, there are always thousands of debts outstanding between the traders in the two countries which have to be settled in some way. This mutual indebtedness is made the means of satisfying the claims on both sides without any coin passing to and fro. Of course, it happens that gold is imported from or exported to France as well as other countries, but the quantity bears no relation to the volume of trade between those countries and England. There being, thus, many people in England indebted to others in France, while there are people in France indebted to others in England, it is clear that if a transfer of the debts could be arranged so that the English debtors could pay the English creditors, while the French liabilities were discharged in a similar manner, an immense saving of trouble and expense would be brought about, while the claims on both sides would be satisfied. This

ACCOUNT SALES OF 10 BALES OF COTTON SOLD FOR ACCOUNT OF W. BROWN, OF LONDON

W B			Per yd	Fr.	c.	Fr.	c.
1–10	4	Bales 1,600 yards @	1.26			2,016	
	6	,, 2,400 ,, @	1.31¼			3,150	
						5,166	
		CHARGES					
		Customs Duties and Landing Charges		252			
		Storage		75	60		
		Insurance		25	20		
		Miscellaneous		75	60		
		Commission @ 2½%		129	15	557	55
						4,608	45

Bordeaux, 1st September, 1905

Jean Bonhomme

Bill at 3 months herewith @ 25.20 = £182 17 6

is, in effect, exactly what takes place, and the means by which it is effected are bills of exchange.

Foreign Bills. For practical purposes foreign bills of exchange are treated as a commodity, and there is a regular market in them as in other articles of commerce. The dealers in this market are known as *bill brokers*, and they make it their business to buy and sell bills drawn on persons in this country by creditors in other countries, and vice versâ. If, therefore, a person in London desires to satisfy a debt to another in Paris or Berlin, he approaches a bill broker and ascertains the price he will have to pay for a bill for the amount he requires. The principal bill brokers, bankers, and merchants meet twice a week at the Royal Exchange and fix the rates for bills on the various countries. The basis of the rate is, as stated above, the par of exchange; but there are many causes operating to affect the market rate. The principal of these is the condition of trade between the two countries. If there is, on balance, a considerable indebtedness from England to another country, there will necessarily be a strong demand in London for bills payable in that country, and the prices of bills of exchange, like those of other commodities, are affected by the laws of supply and demand. The result will be that the English trader will have to pay a premium for the bill he requires, but the premium will be stated in such a way as to somewhat confuse the student in the absence of explanation.

The par of exchange between London and Paris is, as stated above, 25 fr. 22 c. for £1. The rate is said to be above par in London when the exchange is quoted below 25·22, the reason being that in exchange for a sovereign it will be possible to obtain only, say, 25 fr. 15 c., and thus, to discharge an indebtedness in French money a higher price than the actual mint value will have to be paid in English currency.

Gold Points. But there are certain points above or below which the rates with other countries do not rise or fall. These are known as the *gold points*, and indicate the rates at which it would be more profitable to import or export gold coin or bullion to discharge debts rather than buy bills at prices outside those limits. The gold points depend upon the cost of transmitting the gold, plus insurance and other expenses, and the margin, therefore, varies according to distance and other circumstances. In the case of London and Paris, the point at which it would pay to export gold to France is 25·12½—*i.e.*, if it were found that the price of bills was 25 fr. 10 c. a merchant could send bullion cheaper than he could obtain bills. The importing point is 25 fr. 33 c., so that a merchant in Paris would send gold to England if bills on London were above that rate. Although these are theoretically the points of gold movements, it might not follow that gold would be transferred if the rates of exchange exceeded these limits, for the cost of transmission fluctuates slightly, and might do so sufficiently to prevent shipment.

Foreign Bill Procedure. The procedure with regard to foreign bills of exchange differs from that in the case of inland bills. The form of the bill is different, and, as a rule, the wording is as follows:

LONDON, 1st *July*, 1906.

Exchange for Fcs. 7,550.

STAMP 1/6

At three months after sight of this first of exchange (second and third unpaid) pay to the order of M. Jules Perier seven thousand five hundred and fifty francs and place same to our account as advised.

WILLIAMS, JENKINS & CO.

M. F. Chardenal, Marseilles.

Foreign bills are drawn in the currency of the country of the drawee, and are prepared in sets of three. The three parts are in identical terms, except that each is expressed to be payable only in the event of the others being unpaid. The chief reason for drawing the bills in sets was originally with a view to their reaching their destination safely, and that is one reason why they are still so drawn. Another reason is the facility which the method affords for negotiating the bill. The drawer, a merchant carrying on business, say, in Bombay, draws on his debtor in London, and sends over two parts of the bill for acceptance by different mails. He keeps the third, and if he finds subsequently that it would be of advantage to him to have cash immediately, he takes the bill to his banker, and discounts it with him, endorsing it in the usual way. The banker then sends the endorsed part, which, of course, has not been accepted, to his agent in London, who obtains one of the other parts from the drawee duly accepted. The accepted and endorsed parts then form a complete bill, and will be collected when due. The drawee must be careful not to accept more than one part, for if he should do so, and both accepted parts got into the hands of holders for value, he would have to pay both.

Frequently when a creditor in one country draws on his debtor in another, he sells the bill as soon as it is drawn, and the name then inserted in the body of the bill as the payee is that of the person who buys it—generally a banker or bill broker. It will be perceived from this that foreign bills are sold or discounted by the drawers before they have been accepted. This is what actually takes place in many cases, and bills frequently pass through several hands before they are presented to the drawee for acceptance.

Acceptance for Honour. In order to guard against the risk of the drawee refusing to accept the bill when it is presented to him for that purpose, the drawer or any subsequent holder may write on the bill, "In case of need with Blank & Co." This means that in case of the bill being dishonoured owing to its not being accepted by the drawee, the firm named will accept the bill to protect the honour of the drawer or subsequent holder as the case may be. Before they will do so, however, a form has to be gone

through, known as *protesting the bill.* This consists in the bill being formally presented for acceptance by an officer known as a Notary Public, who afterwards makes a declaration in a stated form that he has done so. When a bill is accepted in this way it is known as an *acceptance for honour.*

The banker, or bill broker, who buys a bill from the drawer treats it as part of his stock-in-trade, and either holds it until maturity, or sells it before it is due to somebody who wishes to pay money in the place where the bill is payable.

Payable After Sight. It will be observed that the bill set out on last page directs payment three months *after sight.* This means that the time mentioned in the bill will not begin to run until it has been accepted or sighted by the drawee. Foreign bills are frequently drawn after sight rather than after date, owing to the time which elapses before the drawee receives them for acceptance. When this is the case the bill is presented for acceptance as soon as possible after it is drawn, and the date it is accepted is included in the form of acceptance.

To return to the transaction out of which this short explanation of the principles of foreign exchanges and bills arose. We know that the course M. Bonhomme would take would be to buy from his banker in Bordeaux a bill on London for the amount he has to remit, the price being calculated at the rate of the day. Having obtained it, he sends it to Mr. Brown, who will probably have to first obtain acceptance of it, and then either hold it till it matures or else at once discount it.

Bank Drafts. Another method of making remittances abroad is to purchase a bank draft, which is an order by a banker upon an agent or a branch for the payment of a stated sum of money to the person named in the draft. The drafts can be made payable either at once or at a future time, but in practice they are nearly always sight drafts—*i.e.*, payable at sight or on demand in just the same way as a cheque. They are largely used when remittances of cash have to be made between countries.

English houses which are doing a large business with a manufacturer or merchant in a foreign country will frequently receive the invoices of the goods they buy made out in the currency of the country. The indebtedness will, of course, have to be discharged to the full amount of the invoices. When invoices are received in this form it is necessary for the English house to keep the account with the foreign merchant in both sterling and the foreign currency, the former in order to bring the transactions into line with the other accounts of the business, the latter to know exactly how they stand with the creditor. The method adopted is to fix a rate of exchange at which all invoices received are converted into sterling, the amounts being shown side by side in the ledger accounts. When remittances are made, drafts in the foreign currency are purchased at the rate of exchange of the day, and the cost in sterling and the amount of the draft are entered side by side on the debit side of the account. Finally, a draft is remitted for the difference shown by the currency columns, which will then exactly balance. This result will, however, probably not be obtained in the sterling columns, owing to the varying rates at which the drafts have been purchased. The difference on this column is treated as a profit or loss on exchange, and is carried away to the profit and loss account. The account given on this page shows the working of this method.

Dr. JONATHAN & CO., BALTIMORE Cr.

Date	Particulars	Fo.	$ c.	£ s. d.	Date	Particulars	Fo.	$ c.	£ s. d.
					1906				
Jan. 8	To Cash @ 49½	65	250 00	51 11 3	Jan. 1	By Goods ..	41	250 26	52 2 8
„ 31	„ „ @ 49⅝	75	150 00	31 0 4	„ 28	„ „ ..	63	180 48	37 12 1
Feb. 28	„ „ @ 49¾	84	300 00	62 3 9	Feb. 21	„ „ ..	93	320 76	66 16 5
Mar. 31	„ „ @ $49\frac{11}{16}$	96	257 00	53 4 2	Mar. 6	„ „ ..	114	85 00	17 14 2
	„ Gain on Exchange..			1 7 11	„ 18	„ „ ..	130	120 50	25 2 1
			957 00	£199 7 5				957 00	199 7 5

The fixed rate adopted in this instance for converting the dollar into English money is 50d. per dollar, and the invoices are posted in both currencies, as shown above. Remittances of bank drafts on Baltimore were made on January 8th and 31st, and on February 28th, the drafts being purchased at different rates, as quoted in the account. After making these remittances, there was a balance of 257 dollars due to the American firm, the cost of a draft for which was £53 4s. 2d. The invoices having been converted at a different rate from those at which the drafts were purchased, there is naturally a difference between the sterling columns. This, as stated above, is transferred to the profit and loss account, and if there are many accounts with such differences on them, a special exchange account is opened, and the balance thereof transferred to the profit and loss account at the periodical balancing of the books.

Continued

Group 28
TEXTILES
26

Continued from page 3637

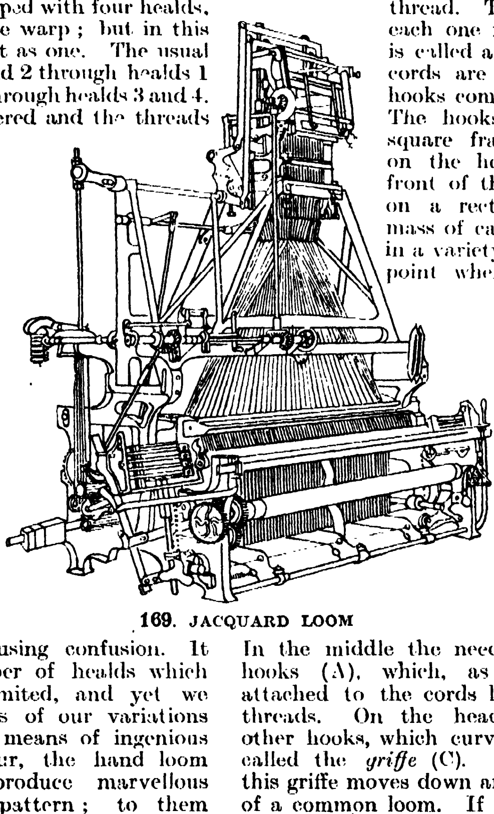
THE FUNCTION OF THE LOOM

Different Methods of Controlling Warp: Healds, the Jacquard, the Tappet, and the Dobby. Loose Reeds. Shuttles; Rising and Circular Shuttle-boxes

By W. S. MURPHY

HAVING viewed the general structure of the loom, we now turn to the various parts with which the weaver manipulates the warp and weft.

The *healds* are those horizontal frames which carry the warp between them and form the *shed*, or opening for the passage of the weft shuttle. For convenience, healds are sometimes called *leaves*. A plain web requires only two leaves, because the one half of the warp crosses the other in regular sequence. When we consider the putting-in of the web, the drawing-in of the threads will be reviewed. For our present purpose we take the loom as ready to work. Many plain looms are equipped with four healds, to lighten the weight of the warp; but in this case, the pairs of healds act as one. The usual way is to put threads 1 and 2 through healds 1 and 2, and threads 3 and 4 through healds 3 and 4. Sometimes the order is altered and the threads are healded 1 and 3 and 2 and 4; but the variation in the order does not matter very much, except for special reasons. It is very different, however, when twills are to be woven. Say that we have a four-end twill to put on the loom, then we require four healds to divide up the warp, because the four sections of the warp act differently. The rule is that every thread in each heald must act in precisely the same way throughout the whole web. Four ends may be easily followed; but when eight, ten, or twelve have to be dealt with, some complexity arises, which only studious care can prevent from causing confusion. It is obvious that the number of healds which a loom can carry is limited, and yet we desire to keep the bounds of our variations as wide as possible. By means of ingenious devices and patient labour, the hand loom weavers were able to produce marvellous varieties in colour and pattern; to them every fresh web was a new problem. But in the factory we cannot proceed upon lines so uncertain. Up till the advent of the Jacquard apparatus into this country, fancy weaving was done mostly on the hand loom; but that wonderful contrivance changed the situation entirely, and opened a career for the power loom far grander than ever the hand loom, with even the harness apparatus, could claim.



169. JACQUARD LOOM

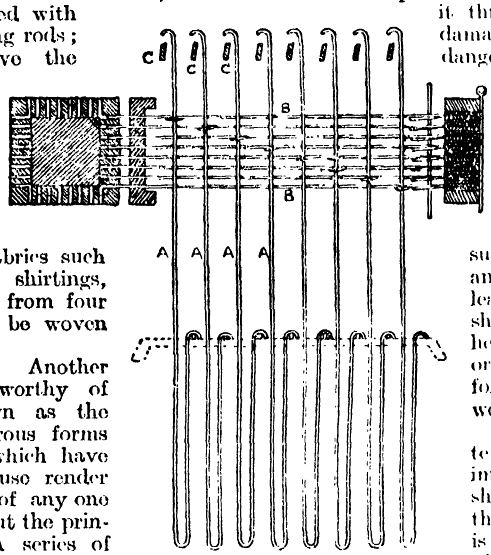
Jacquard. This machine presents some difficulties to the learner at first; but, if taken in detail, and each part noted with care, the whole should appear plain. Looking at the jacquard loom [169] we see that over the face of the warp is spread a mesh of cords, which, at first sight, seem to baffle understanding; but these are simply the heald cords stretched out and applied in this way. As every heald cord holds its own particular thread, so these cords have eyelets which each hold a warp of thread. The cords converge, and each one is knotted on to what is called a neck cord. The neck cords are short, and loop round hooks coming down from above. The hooks extend up within a square frame seated above all on the head of the loom. In front of the frame and revolving on a rectangular cylinder is a mass of cards, pierced with holes in a variety of patterns. At the point where the cylinder brings a card in front of the frame is a board pierced through by a mass of needles, to the depth of a quarter of an inch. Now look inside the frame [170]. At the inner extremity of the projecting needles (B) is a box full of springs which allow the needles to give way to pressure, but send them back again as soon as the pressure is removed. In the middle the needles are joined to the hooks (A), which, as we have seen, are attached to the cords looped round the warp threads. On the heads of the hooks are other hooks, which curve into a series of bars called the *griffe* (C). As the loom works, this griffe moves down and up, like the treadles of a common loom. If all the hooks were left in place, the bars of the griffe would lift them up bodily, and so elevate every thread of the warp. We do not want anything of the sort. Governed by an action of its own, the cylinder brings round the cards to the needle board, and the cards press back those needles which have no perforations opposite to them. The

needles, being pressed back, send the hooks to which they are joined out of the way of the griffe; the griffe, in its passage upwards, lifts only those hooks which the perforations of the cards have allowed to remain in position. These hooks pull up the corresponding warp threads, and the shed designed is made.

One needs little consideration to understand what a wonderful instrument the jacquard has placed in the designer's hands. By its means we can manipulate every individual thread in the warp in any way desired. The cards are pierced according to design, one perforation for every warp thread to be called up. Some designs require as many as 20,000 cards.

The Tappet. Other methods of manipulating the warp have been devised. One of the earliest and simplest was the *tappet* motion, consisting of treadles, tappets, jack-levers, square shafts, and half-moon levers. The wheel-shaped tappets move on the treadles, the ends of which are connected with the jack levers by long rods; the jack-levers move the square shafts extending across the loom, and set in motion the half-moon levers, which, being connected by cords with the healds, perform the shedding motion. Fabrics such as doeskins, cotton shirtings, and twills, requiring from four to eight healds, can be woven very well by tappets.

The Dobby. Another shedding machine worthy of note is that known as the dobby. The numerous forms of this contrivance which have been brought into use render detailed description of any one almost needless. But the principle is general. A series of pegs act on a set of blades, which perform the same office for the pairs of levers controlling the healds from above and below as the needles of the jacquard to the wires. When the peg puts a lever out of position, the heald is depressed; when the blade remains in position, the heald is elevated, and with it, of course, the warp it controls. A modification of the dobby is seen in the velveteen loom [171].



170. DIAGRAM OF JACQUARD

The Reed. Though nothing more than a series of flat wires set under the slay, the reed is not a simple instrument. In the plain loom we have no more to do than put two or three or more threads from the healds through between each pair of reed wires, or in each *dent*, as the opening between the wires are named. But the moment we begin to depart from the plainest of plain cloth our troubles with the reed begin. Take two twills for example. Say one flushes two ends and two picks alternately, and the other flushes three picks and three ends. If both were reeded the same, the former would be too thin, or the latter would be too thick. Reeds vary in closeness, some having 10 and others as many as 16 dents to the inch. Thickness of thread also has to be considered in reeding. All this is a matter of calculation, however, easily arrived at by arithmetic.

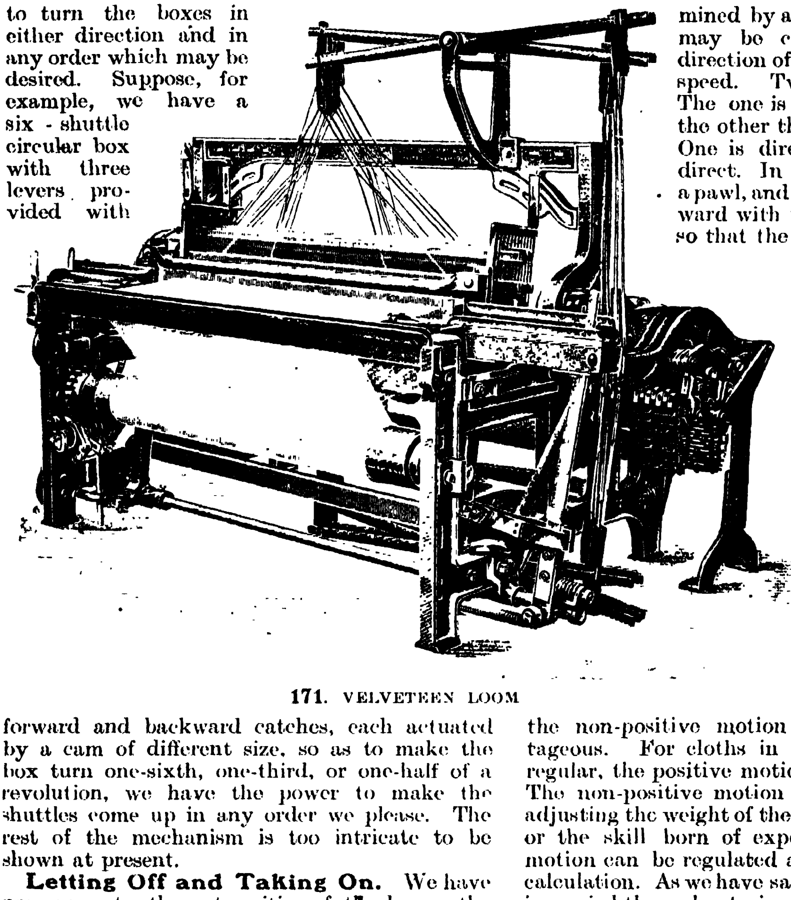
Searching for ways of carrying out novel designs, the designer has hit on a method of utilising the reed in the formation of crinkled cloths. Behind the reed, and timed to act at the moment when the reed is being thrown back, a series of little nippers comes up and grips on to a range of warp threads just for an instant, holding them back while their fellows go forward, thus putting a series of drawn threads through the fabric. Other small services are imposed on the reed, but these are of minor value.

Loose Reeds. Should the shuttle by any accident be turned from its course, and tangle in the warp, the coming of the reed will smash it through the warp and cause damage. To guard against this danger there have been several kinds of loose reed invented. The best is the simplest. Instead of fixing the reed solid in the slay, the lower side is held by a spring clasp, which tightens at the moment of the stroke of the slay just sufficient to give the stroke, and slackens so as to offer the least resistance possible to the shuttle at any other time. For heavy goods, however, the ordinary fixed reed is best; for light cloths the loose reed works very well.

Shuttles. Numerous attempts have been made to improve on the common fly-shuttle, but the form has, in the main, kept unchanged. It is true that the stiff wooden pirn, with its screw, has given place to the weft cop, with the consequent alteration in the method of securing it in the shuttle. Some shuttles have a spring lid, others let the weft out from the centre of the cop; but most have merely a peg at the end, where the screw-pin used to be. The chief property of a shuttle is that it will let the weft come away easily and fly straight. In these essential qualities the old form of shuttle excels all others.

Shuttle-boxes. When the power loom came into general use, the first demand was for a shuttle-box which would change the shuttles automatically. Without the ability to change the shuttles swiftly, vari-coloured weaving was an impossibility. Kay the younger had already shown the way with his springing change shuttle-box, and subsequent inventors took the hint. Now we have two systems, or methods, for changing the shuttles. The one is by what are called *rising boxes*, the other is the *circular box*.

By means of springs adjustable to the requirement of the design, the shuttle-boxes sit one above the other, and change places with marvellous rapidity. Before beginning to weave, the plan of the rising boxes is arranged on the jacquard principle, so that each shuttle comes up in turn, as needed by the pattern. On fancy cloth and gauze looms, the six boxes are placed at both ends of the lay, the 12 shuttles affording special opportunity for fine weft effects. Circular shuttle-boxes move with less noise, and possess other points of merit. The shuttle-boxes are fixed round a centre, the revolving motion being conveyed through levers and cams acted on by the motions of the loom. When first introduced the circular boxes could be moved in one direction only, and in direct succession. By a rearrangement of the gearing we have been enabled to turn the boxes in either direction and in any order which may be desired. Suppose, for example, we have a six-shuttle circular box with three levers provided with forward and backward catches, each actuated by a cam of different size, so as to make the box turn one-sixth, one-third, or one-half of a revolution, we have the power to make the shuttles come up in any order we please. The rest of the mechanism is too intricate to be shown at present.



171. VELVETEEN LOOM

Letting Off and Taking On. We have now come to the extremities of the loom—the warp and the web beams. The relations between the two are very intimate, though they are as far apart as possible. The warp must be let off in such measure as the taking up of the cloth beam requires. Not only so, but it should keep the warp even and tension uniform. In their mutual relation, the cloth beam is the active and the warp beam the passive agent. It is the former which draws. The latter, therefore, needs little more than the means of holding back. As a rule, the warp beam is weighted, the weight being proportioned to the character of the cloth and various other circumstances which can hardly be defined in any theoretic way.

Cloth Beam. The management of the cloth beam is not so simple; it must be regulated in a stringent fashion. Consider how many different variations the cloth beam has to meet. We may want to spread the weft over a wide surface, varying the number of picks to the inch by 20 or more. Or it may be that the cloth is to be heavy with weft. Then the weft may be thin or thick, single or double. For every variation the cloth beam must have a certain rate of movement. This movement is derived from the action of the loom, and the rate is determined by a train of wheels which may be changed either in the direction of increase or decrease of speed. Two methods are used. The one is called the *positive* and the other the *non-positive* motion. One is direct and the other indirect. In the latter a lever with a pawl, and weighted, is driven forward with the motion of the slay, so that the pawl, or catch, pushes round the toothed wheel on the end of the cloth beam. According as the weight is light or heavy, the cloth beam yields less or more to the action of the slay. Here the thickness of the thread will have a strong influence on the movement of the cloth beam, because, the thicker the thread the harder the drive. In weaving woollens, or cloths in which the thickness of the weft threads vary, the non-positive motion is distinctly advantageous. For cloths in which the yarns are regular, the positive motion is to be preferred. The non-positive motion is merely a matter of adjusting the weight of the lever by a rough guess or the skill born of experience; the positive motion can be regulated according to scientific calculation. As we have said, the positive motion is carried through a train of wheels. The first of the train takes its motion from the loom, and the others are moved by it. If we vary the number of teeth on the wheels which are driven, we obtain a difference in the rate of speed. The value of each wheel is measured by the number of teeth to the circumference; by combining these values we get the speed at which the last wheel or the cloth beam is being driven.

Continued

FITTING, ERECTING, & ASSEMBLING

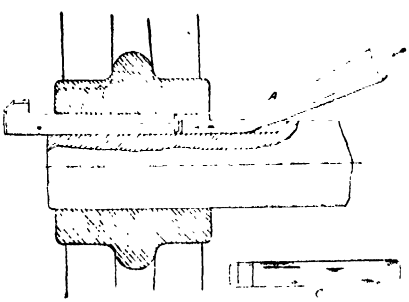
Approved Practice in Modern Fitting and Erecting Shops. Chipping and Filing, Erecting, Levelling, Hoisting, and Assembling

WORKSHOP PRACTICE continued from page 36[illegible]

By JOSEPH G. HORNER

THE terms *fitting*, *erecting*, and *assembling* denote distinct departments of shop practice which follow the operations of the turnery and machine shop. In each the individual parts are built up into the relations which they have to occupy permanently. Fitting signifies the bringing together of certain sections only, as the parts of a cylinder, or the link motions, or the connecting rod ends, or a set of gears, etc., which have afterwards to be built into the complete engine or machine. Erecting and assembling both denote the latter operations—the final completion of a piece of mechanism all ready for service. But there is a most important distinction between the two. Erecting signifies the building up by means of mutual adjustments of connections by filing, scraping, reamering, by methods of trial and tentative settings. Assembling denotes the bringing together of parts without any corrections or adjustments, similar machined pieces being taken at random, and fitting at once into their place in any similar machine, being characteristic of the interchangeable system already alluded to in our study of the turnery and machine shop. These two methods have little in common. Erecting is the older system, still unavoidable in massive constructions; assembling is the modern. The tendency is to the substitution of this latter system for the older in the manufacture of articles of small and medium dimensions. The economies secured thereby are enormous. The system is indissolubly associated with that of gauging, and, therefore, methods of measurement are an essential feature of it—gauging involving absolute dimensions as distinguished from measurements involving mutual fitting and correction.

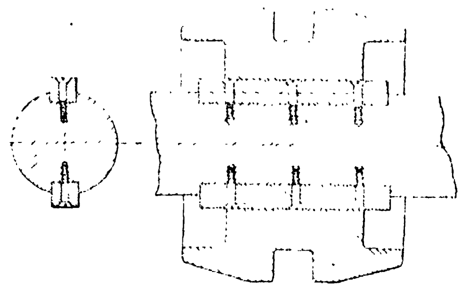
Fitting. Narrowed down to its strict meaning, this signifies the making of mutual contact



309. REMOVING A KEY

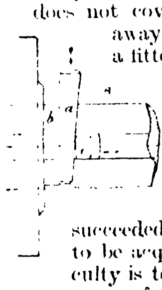
between parts, the nature of which contact varies. It may be that of plane or of curved surfaces. Fitting also may be tight or free. It may, further, be something very exact to dimensions or approximate only, fine fitting or coarse, and that of soft or of hardened surfaces. In the construction of mechanisms there is a wide field for all grades of workmanship.

Chipping and Filing. In the older practice, chipping occupied a much larger place than it does in the present. It is a roughing down operation preliminary to filing, and is accomplished



310. SUNK, OR FEATHER, KEYS

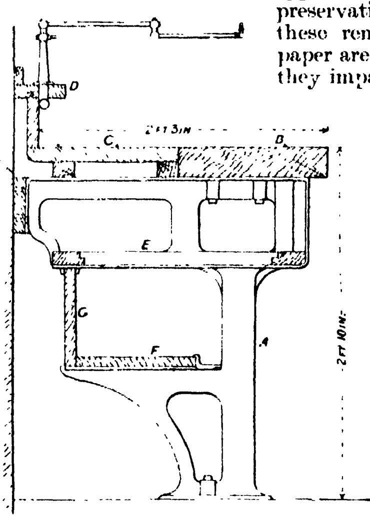
by cutting small chips by hammer blows directed on the head of the *cold* chisel. The chisel is doubly bevelled, and is made in different widths, ranging from ¼ in. in the *cross cut*, to ¾ in., or 1 in., in the *surfacing* chisel. The cuts are generally made to cross each other at various angles. If a large surface has to be done, the cross cut is used to form a series of grooves, leaving intermediate spaces to be dealt with more easily by the broad chisel than if the whole of the work were done by this tool. Chipping must never be done closely towards an edge, as it might cause the metal to break out, but away from it, or in a diagonal direction. The portable machine tools have taken much of this work, because, when pieces are too massive to be taken to a machine, the portable tools are fixed to the work. This does not cover the case of repairs, jobs done away from the workshop, and therefore a fitter must be able to chip when the necessity arises.



Rough filing follows chipping. Either the coarse, rough cut, or the bastard files are used first, followed by the fine or smooth grade files; and when great accuracy is required, these are succeeded by the scrape. Filing is an art to be acquired only by practice. The difficulty is to file *flat*. Only dead parallel files are perfectly straight; all others are more or less bellied, which shape is favourable to the production of flat faces. The right elbow is kept quite close to the workman's body, the body moves in unison with the file, and its weight is thrown into the forward

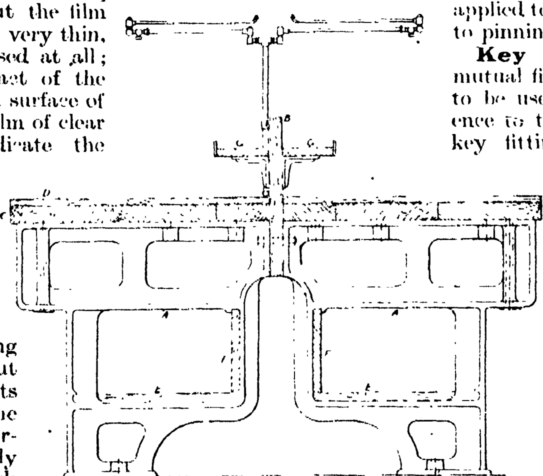
stroke and relieved during the return stroke, though the file is not actually lifted off the work. Economy is sought by crossing the direction of the strokes at intervals. Frequently time may be saved in heavy filing by using the backs of half-round files before the flat files. The fine files should not be employed until the surface has been brought nearly level, and nearly to a finish.

Testing. The testing of plane surfaces is done with straightedges, winding strips, and surface-plates. Red lead paste, made with red lead and oil, is rubbed on the edge of the straightedge or on the surface of the plate, and indicates by its transference to the high parts of the filed surface the localities from which material has to be removed. As the correction approaches completion, the action of the file has to be localised by shorter strokes, or by operating with an inch or two only next the point. The red lead must then be applied more thinly. When the surface shows contact nearly all over nothing more can be effected with the file, but the scrape will be brought into service. This is held at an angle of from 30° to 40° with the surface of the work, and it removes the merest trace of metal from the high localities. The surface-plate is still used to check results, but the film of red lead must be very thin, or else it is not used at all; but the mere contact of the work with the clean surface of the plate, or a thin film of clear oil suffices to indicate the points of contact. The surface of the work must be wiped clean every time of making contact.



311. CAST-IRON BENCH

Mutual Fitting. It will be noticed that nothing has been said about making mutual fits between parts. The reason is that the surface-plate is the only test, and the work goes together for bolting or sliding fits as it leaves the test of the plate. If parts were fitted mutually, inaccuracy in one would produce similar inaccuracy in the other, but of opposite kind, as concave and convex, etc.

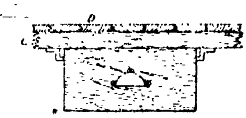


312. DOUBLE CAST-IRON BENCH

But there are many cases of mutual fitting of one part to another when one is known to be true. Thus bearings are generally fitted to their shafts in good work by scraping. The shaft is true, but for various reasons bearings are scraped to make easy fits with the shafts. The scrape is then worked edgewise in the brass, and red lead is smeared on the shaft journal.

Cautions. The practice of filing is of extensive application; but with some remarks on the preservation of the file, we must close these remarks. Though emery-cloth or paper are often used subsequently to files, they impart only a smooth finish. They do not effect accurate results, which can be produced only by scraping. The same remark applies to finish imparted by draw filing. A good file must never be used on the outer, hard skin of a casting or forging. If this has to be removed by filing, an old, practically worn-out instrument must be used. Or the skin can be removed by grinding if the allowance left is small, or by chipping if sufficient in amount. Or the work may be pickled as for machining in dilute sulphuric acid. A new file should not be used on wrought iron and steel, but on brass and gun-metal first, because partly worn files will not cut these alloys well, but will slip over them while they are yet capable of working on wrought iron and steel. Files that become clogged or *pinned* with particles of steel can be cleaned with card-wire; or chalk, or a little oil applied to the file lessens the liability to pinning.

Key Fitting. A section of mutual fitting in which the file has to be used generally without reference to the surface-plate is that of key fitting. On correct contact

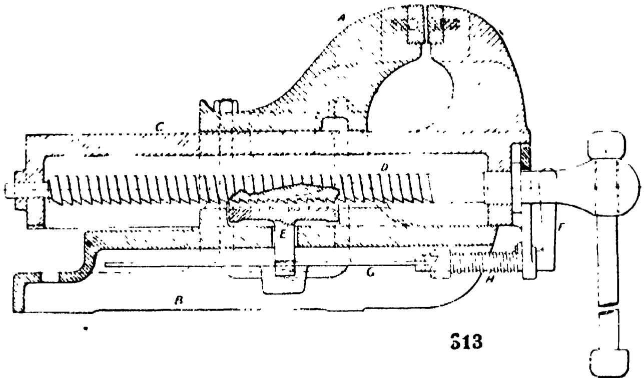


between keys and their seats the steady running of wheels largely depends. Although keys are driven hard into their seatings, this without good contact all over would not suffice for permanent results, but they would work loose in time. Either the key may be fitted to its seating or vice versâ. A key should be planed or ground truly, and it may be tested on the surface-plate. If the groove has not been slotted truly, then it, rather than the key, should be corrected by filing. But it is usually more convenient to ease the key to fit its seating, and the slot is usually assumed

to be true. To effect this it is driven in with moderate force and then removed, the bright marks caused by friction with the key-bed indicating where to file off metal. Red lead or chalk is rubbed on the key before driving in, to help to show the high spots and prevent seizing. After filing, the key is again driven in and removed, the process being repeated until good contact is obtained and the key is sufficiently let in.

The removal of keys during fitting is done by the key drift [309 A], driven with the hammer when it is possible to get through the back of the keyway; or as 309 B, with a wedge (*a*) and packing (*b*), which is advisable only when the key (*c*) is supported by the key-bed in the shaft. Often, however, when the drift (A) cannot be got in, a wedge is used, and the head of the key is supported by holding a heavy sledge hammer to prevent bending down, which would involve subsequent straightening. Fig. 309 C shows the appearance of the key top when the contact is only partial; the aim of the fitter is to make the friction marks appear all over.

Sunk, or feather keys [310] are let in the shaft, and the wheel, etc., driven over them, removal and filing being done several times as necessary. When the clutch has to slide as in 310, the feathers are secured by countersunk screws, or sometimes rivets, to prevent their working loose. Fitting is a question of filing the tops and sides of the feathers until the clutch slides freely, but without shake, special care being taken that good contact is made along the sides, otherwise loose working will soon ensue.



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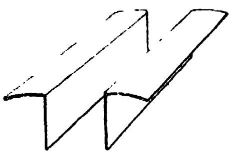

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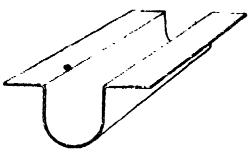

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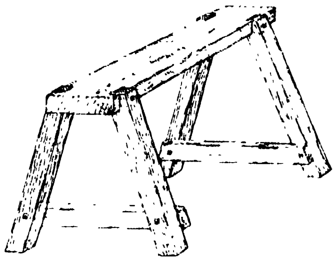

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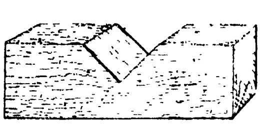

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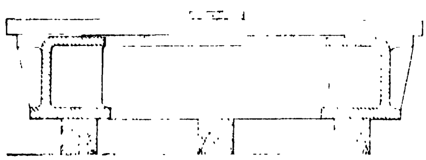

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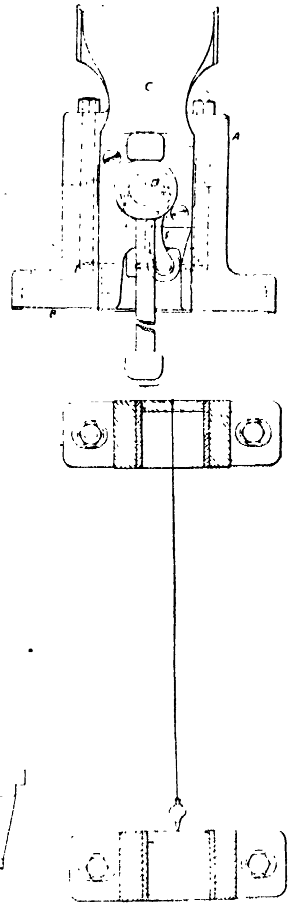


319

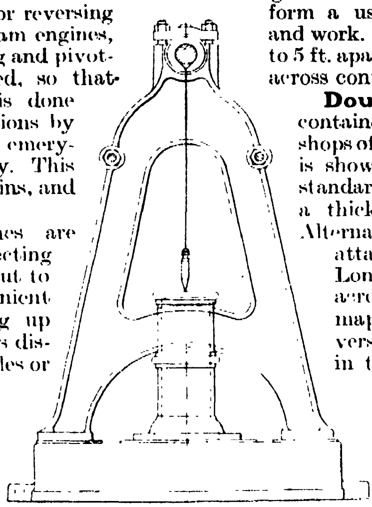
FITTING-SHOP APPLIANCES

313. Parkinson vice **314** and **315.** Vice clams **316.** Trestle **317.** V block **318.** Testing foundation with straight-edge and spirit level **319.** Testing bearings by plumb line

Cottared Joints. A special type of fitting allied to the keys is that of cottared joints, with or without gibs. Though the parts are machined, some adjustments are usually necessary in the cottar holes and in the cottars and gibs. The same methods of filing and checking with red lead are adopted, but as the number of pieces involved is greater,

considerable care has to be exercised. A complete joint of this kind will include the stub end of a rod, the brasses and strap, the cottar, and one or two gibs, with or without set screws. Link motion, or motion work for reversing and operating the valves of steam engines, is high-class fitting. The sliding and pivoting surfaces are case hardened, so that though the principal fitting is done before hardening, some corrections by scraping or grinding, or with emery-cloth, are necessary subsequently. This includes the links, die blocks, pins, and pin holes.

Benches. Fitters' benches are necessary in all fitting and erecting work, not only to carry vices, but to afford a surface at a convenient height for laying and building up the small parts of mechanism, as distinct from those erected on trestles or on blocking on the shop floor. The bench also carries small tools and various appliances, some in drawers.

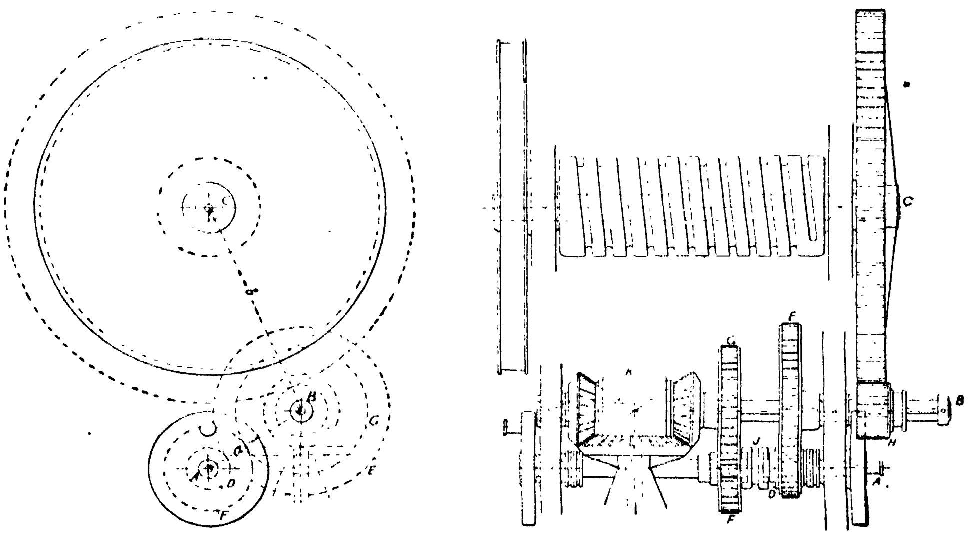


320. TESTING CYLINDER CENTRE BY PLUMB LINE

The common timber benches built up something like that of a carpenter, but carried along for a considerable length, have given place in many shops to those of cast iron, which are more rigid, durable, and cleanly. An example to go against a wall is shown in **311**. The cast iron portion consists of the leg or standard (A) fastened to the floor with a coach screw, and to the wall with a couple of countersunk screws entering a wood packing. The thick piece of timber (B) forms the front of the bench top, and stands the heavy work, as well as carrying the vice which is held by a bolt passing down through the boss seen near the front of the casting. At C a thinner timber is used, packed up on strips ; a narrow shelf (D) is supported above C to carry small tools and the gas or electric light fittings. The frame for the drawer is mounted inside the casting at E, and a lower shelf (F) and back (G) form a useful addition for holding tools and work. These legs are placed from 4 ft. to 5 ft. apart, the timbers, of course, running across continuously.

Double Bench. A double and self-contained design, such as is used in the shops of John Lang & Sons, of Johnstone, is shown in **312**. Here two cast-iron standards (AA) are bolted together, with a thick piece of timber (B) between. Alternatively, one leg alone may be attached against a wall, as in **311**. Longitudinal timbers (C) are laid across, and then faced with hard maple $1\frac{1}{8}$ in. thick, placed transversely and tongued together as seen in the front view, showing also the drawer hung on bearers screwed to the underside of the planks (C). A deep boss is provided, as in the previous example, for attachment of the vice. E and F are shelf and back boards to carry work in progress clear of the floor. Small shelves (G) are attached to the upright (B), and a gas-pipe is also supported thereby. The height of such benches averages 2 ft. 10 in. to the top of the board.

Vices. Fitters use both the ordinary screw and the instantaneous action vices, the advantage of the latter being that the jaws may be opened and closed instantly to any size without the tedium of turning the screw many times. The Parkinson vice, a combination type, is seen in **313**. It has a fixed jaw (A) bolted down to a base (B), and embracing the sliding jaw (C). The latter carries a buttress thread screw (D),



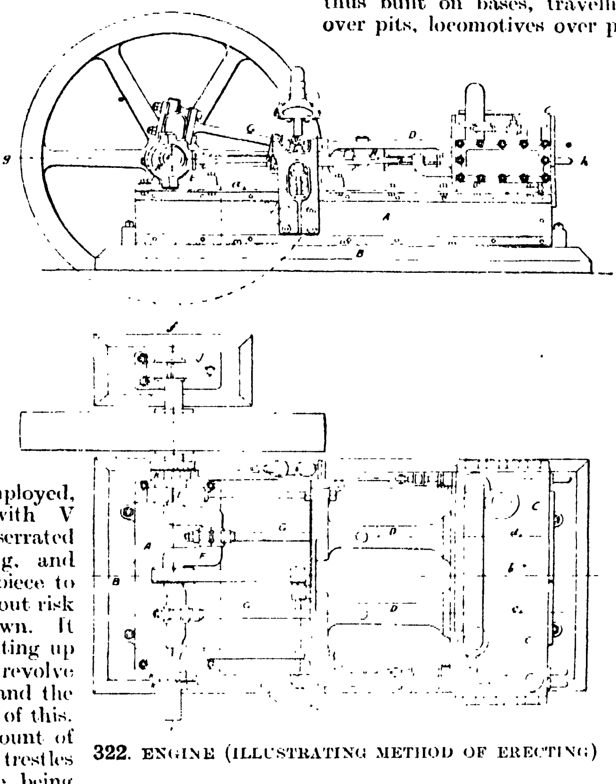
321. MARKING BEARING CENTRES FROM GEAR WHEELS

fitting a half nut (E) lying in a recess in B. The screw, or the instantaneous action, is alternatively brought into operation as desired, according to whether nut E is lowered out of mesh with D (as seen), or whether it is raised up to engage. In the first case the jaw (C) may be slid freely to and fro; in the second it can be moved only by turning the screw by the long handle, acting then as an ordinary screw vice. The movement of E is produced by the lever F, which, when clasped by the hand to the knob of the screw (D), turns the flat strip (G) lying in a groove in E, and lowers the latter. When F is released the spring (H) draws it outwards, pressing E upwards, so that in the normal state the vice remains a screw one.

Clams. Clams are necessary for much vice work on finished surfaces, the hard steel serrated jaws being only suitable for black or rough work. Sheet iron or copper clams **[314]** are suitable for ordinary use, but for brass or other soft work thick lead clams are desirable. Various special forms are also employed, such as those with V grooves for rods, serrated grooves for piping, and those made in one piece to support shafts without risk of their slipping down. It is very handy in fitting up shafts to be able to revolve them at intervals, and the clams in **315** permit of this. A considerable amount of fitting up is done on trestles **[316]**, two or more being used for a piece of work. Shafts are supported thus for key and other fitting, resting in V blocks **[317]**, often in preference to using the bench vice, because the latter is not so convenient, and does not allow the workman to walk all round the job.

Erecting. Erections are assumed to deal only with rather heavy work which cannot be done on the bench. Work completed on the bench is properly fitting, so that a pump or small motor, if bench work, would be classed as fitting; but a large pump or engine put together on the floor would be erecting.

Levelling. Erecting generally involves dimensions or relations too large for the employment of rules and small instruments of measurement. Hence, the spirit level and the plumb line are of regular utility. Hence, too, most work is built up from a truly horizontal foundation of some kind or another, which may be either a part of the machine itself or an artificial and temporary basis. Most engines and machines have some kind of solid foundation in the form of bed, bed-plate, base-plate, or base in one continuous length, or in two or more disconnected parts. In erection, these are levelled up truly horizontal by means of a spirit level laid on a straightedge **[318]**. Usually they are levelled and wedged up on heavy timber blocks cut from balk **[318]**. When there is much work of the same kind, a permanent foundation is laid in the shop, on which to bolt the actual foundation of the engine or machine. Some cranes are thus built on bases, travelling cranes on rails over pits, locomotives over pits, marine engines down in pits, and so on. In each case before any superstructural work is done the actual foundation is fixed and levelled, and any necessary fine adjustments are made by wedges. Once levelled it remains permanently fixed until the superstructure is completed over it.



322. ENGINE (ILLUSTRATING METHOD OF ERECTING)

Reasons for Levelling. The necessity for levelling is to have a basis from which to erect perpendicular faces and centres, and also to ensure parallelism of all parts that lie in horizontal planes. If the base is levelled, all other horizontal faces are fixed by the employment of the spirit level. If perpendiculars are erected, all perpendiculars and horizontals must obviously be at right angles with each other without any need to set by squares, though this would still be done in the case of short or low faces and centres. But the use of a square is obviously impracticable when heights of many feet are concerned. Neither can a square be applied in many cases where a plumb line can be, as through the centre or axis of a bearing for example. The practice of levelling can be extended to include bearings for shafts which may have no other bases for adjustment, and for bearings standing at right or other angles with each other. The bottom of the bore is then used for the working base, parallel straightedges being laid therein and receiving the spirit level on the top edge. Another way is to lay the actual shaft in its bearings, and level the top edge of the shaft.

Straightedges are necessary in all levelling where the length or area to be checked exceeds two or three feet, and they must, of course, be parallel, the bottom edge coming on the work, and the level resting on the top edge. It is necessary also to turn the level about end for end in case the instrument should be out of truth. Or levels with an adjusting screw may be used.

The value of a truly horizontal base is seen at every stage of subsequent erection. If measurement be taken from that base to any centre above, the spirit level ensures parallelism. If shafts or faces are not situated perpendicularly over one another, so that direct measurement cannot be taken, each one can be measured directly from the base. Parallel parts in the horizontal plane can be measured off at any height from the base by dropping a plumb line and by taking horizontal dimensions therefrom. Bearings in the same perpendicular axis are centred by dropping a plumb line through the centre of the upper one [**319**], the bob coming over the centre of the lower one, both bearings being bridged with wood on which to get the centres. A bearing above can be centred by a plumb bob over a centre on the base plate below, or to one side of such a centre to any dimension. The centre of a cylinder can be located plumb with a shaft bearing similarly [**320**].

Centres and Edges. The measurement of distances between shafts or faces is variously done, sometimes by centres, sometimes by edges. The latter is, as a rule, the more convenient method, though centres are the dimensions laid down on drawings, and when lining out work. In erecting it would often be difficult to employ centres. Having shafts or faces in the same plane, calipers or a rod gauge are generally employed in preference to the rule, measurement being taken between the adjacent shafts or faces. If they are not in the same plane then a parallel straightedge may generally be carried along and set horizontally by means of a level, and measurement taken from that to the second shaft or face.

Straining Line. In some cases a straight cord or fine wire is employed as a centre from which to take measurements. This is most convenient in engine erecting. The wire is strained taut down the centre of the cylinder bore, retained centrally by strips in the ends, and being carried beyond to the guides and crank shaft bearings, measurement is taken therefrom. The same device is employed in testing shaft bearings arranged in line along a shop wall, or along the girder of an overhead travelling crane. It is also used in order to observe the amount of set, or deflection, which a beam or girder undergoes when loaded. An alternative to the strained cord in the adjustment of bearings in a horizontal plane is to lay the shafting in, in successive lengths, levelling each length in turn with the spirit level, and coupling up as the work proceeds. The strained cord would still be employed for checking dimensions laterally. In a long length of shaft involving numerous bearings, a wire would sag or drop slightly, hence the preference given to the spirit level, but it would not sag laterally.

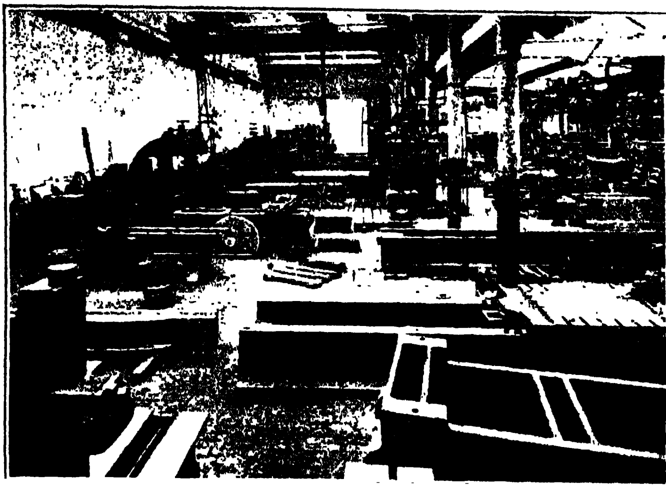
When pieces of work have angular relations in plan, and dimensions are large, the plumb line is usually preferred to the square or bevel. The relations of right or other angles are marked on the base, or bed plate, by geometrical methods preferably, but never by small instruments, the errors in which would be magnified, and the plumb line is dropped to these lines. In small work, of course, squares and bevels are employed.

In setting and checking dimensions it is necessary to be careful to avoid errors, which are less likely to arise in working by centres than by edges. Addition or subtraction for thicknesses and semi-diameters have to be made, and allowances for any inaccuracies in rough work. A safe course to adopt when there are a number of dimensions in one plane is to add them all, and see if they total to the correct overall dimensions. This serves to check both the drawing and the workman's reckonings out.

Gear Wheel Centres. A part of the erectors' work is often that of lining out. Thus, it may happen that certain centres cannot be obtained until the centres of gear wheels have been determined. When there are trains of iron and steel wheels with cast teeth, shrinkages and exact centres cannot be determined beforehand. Hence, the centres of bearings are often marked out from the wheels themselves. Fig. 321 illustrates a typical set of gearing. The shafts A B C have to be connected

323. FITTING SHAPING MACHINES IN LARGE NUMBERS
(Hendey Machine Company, Torrington, Conn., U.S.A.)

at centres which are fixed by the gears, and A and B have two sets of gears of different sizes, so that, if any inaccuracy occur in these, it has to be averaged between the two in setting the centres of the shafts. D E are for slow lifts, and F G for quick. The centres are *a* and *b*, and generally the locations of one or of two are fixed by other fittings or movements. Cast steel gears often give much trouble in centres—more than those of iron do, because of their greater and uncertain shrinkage; hence, one reason for the growing popularity of cut gears, the diameters of which are exact. The shaft fittings include the keying up of fixed gears, and the fitting of the sliding or feather keys and pinions. The latter are slid with a clutch motion, H, or a sliding clutch engages with the gears as at J and K.



324. ERECTING PLANING MACHINES (C. Redman & Sons, Halifax)

Erecting an Engine. Fig. 322 illustrates a compound horizontal engine which will serve as an object lesson on erecting of the class of which it is typical. In any work of this kind there are, of course, alternative methods, into which we cannot enter. But, broadly, there are two ways in which such an engine could be erected, one being by taking section by section, and measuring and checking each; the other by doing all the machining by templets and gauges made from a first engine completely fitted up, and then taken apart and each part being used as a templet, or gauge, or employed to make these from. This method is suitable when a considerable number, say above ten or a dozen engines, are wanted all alike. This is a half-way device between erecting and assembling; for slight adjustments would have to be made, as reamering of bolt holes through parts in place, and casings with file and scrape. Yet for a class of work of medium size these slight corrections would not invalidate the term "interchangeable" applied to such a class of work, though not in the stricter sense in which it is applied to the smaller mechanisms.

Engine Bed. In 322 the engine bed is shown at A as built up of plate and angle, alternatively to a casting. The top face, *a*, is levelled first, irrespective of the truth of the bottom face which goes on the foundation, B, of masonry and concrete. The top, *a*, is planed level, and the bottom might be also, or be left rough. But *a* is the face to be levelled, both before erection of the engine in the shop, and at the time of its erection on its foundation, B. A centre line, *b*, is run along the bed, and to right and left of this the centre lines, *c*, *d*, of the cylinders are marked, and at right angles with these the line, *e-f*, for the crank shaft, and by these the principal work is done. In the other direction the important centre is *g-h*, corresponding with the axis of the cylinder, cross head, and crank shaft in the horizontal plane.

Details of Erection. In the figures the cylinder lagging conceals the joints, but the two cylinders are cast separately, and bolted together. In some cases they are cast as one. But in either case the machining is finished—boring, facing, etc.—before they are put on the bed plate, and if cast separately, they are bolted together before being attached to the bed plate. They are then clamped to the bed plate, and bolt holes drilled and reamered, after due checking of the longitudinal accuracy of the cylinder axis. Being set over their centres, a straightedge is passed down the bores to the crank shaft, provided the guides, D D, are not cast with the cylinders, and lateral measurements taken there. Or a cord or wire is strained down the centres through wood strips bridging the ends, and measurement taken from that before the final reamering is done. The crosshead guides, D D, are shown as cast with the cylinders. Often they are cast separately and bolted on. If so, they are attached to the cylinders before the latter are bolted to the bed plate. The piston and piston rods, together with the glands and covers, will have been fitted to the cylinders at the bench, and these will be removed during the setting of the cylinders by the straining line. By the same line the positions of the crank shaft bearings, E E, will be adjusted laterally, before their bolt holes are drilled and reamered. The bearing centres will be squared up from the centre line *e-f*, scribed on the bed. The crank shaft, F, is now dropped in, and the connecting rods, G G, fitted to the shaft at one end, and the cross heads, H, at the other. If, however, these parts had all been made by templet from a sample engine, then the cylinders, guides, and rods would be set bodily at once, and connection made to the crank shaft with no settings and adjustments, except, perhaps, a slight amount of reamering of bolt holes. The

position of the bearing J, independent of the main bearings, E E, is set with a straightedge from the bores of E E. When it is fixed, the crank shaft, having the flywheel keyed on, is dropped into place, and the caps screwed down. The eccentrics, K K K, for operating the valve rods are, in a templeting system, keyed on their shaft before erection, but in much average erecting the keyways are not cut until the engines are fitted. The steam chest covers are removed, and the valves set for lap and lead, with the piston rods at extreme travel. The eccentrics are set corresponding with these positions, and keyways then marked and cut. The pump and governor are not main fittings. They are set and bolted up by centre lines, as are some other fittings indicated but not referred to. Figs. 323 and 324 illustrate interiors of shops where fitting and erecting are both done.

Joints. In steam and hydraulic work, the making and packing of tight joints is an important detail. In the best work steam-tight faced joints are made by scraping alone, and no substance is interposed, except a thin film of red lead in oil. But when faces are left rough-turned or planed, insertion sheet is used, as wire gauze, canvas, American cloth, each smeared with red lead or tallow. Indiarubber or asbestos sheet are considered better. Some joints are made simply with a ring of copper wire, some with millboard, or with tar twine. All stuffing boxes have to be packed. A good deal of metallic packing is used now, but the spun yarn, or soapstone, or asbestos packings retain their place in favour. Hydraulic packings are more troublesome than those for steam ; leather is invariably used for high pressures, and these are of cup, or U, or of hat shapes, so that pressure tightens them between the ram and cylinder.

Hoisting. In heavy erections, hoisting tackle of various kinds is in constant use. The self-sustaining pulley blocks and tackle are extremely valuable, since they can be employed for heavy loads and sustain them safely in any position. They are frequently slung from a beam attached to the trolley of a wall jib crane. But they are too slow in operation for much work, for which an overhead travelling crane is necessary, which, covering the whole area of the erection, is yet clear of it, and is also rapid in travelling, in cross-traverse, and in hoisting.

For making adjustments for which a crane is not suitable, or in the absence of a crane, jacks of screw or hydraulic types are used. They are employed in levelling up bedplates and foundation plates on the timber blocking, and for effecting slight horizontal adjustments.

Assembling. Assembling is possible only when interchangeability of similar parts is carried out absolutely, for any fitting, however minute in degree, is incompatible with it. To ensure absolute uniformity of parts the machining must be controlled automatically, as has been explained in connection with the work of grinding and milling machines, and the turret lathes. Thus, the demand for interchangeability has favoured the development of these machine tools, and these in turn have quickened the growth of the system.

Limits of Tolerance. But though these machines, with their arrangements and fixtures ensure uniformity in a hundred, or a thousand, or ten thousand similar pieces, it is obvious that slight inaccuracies must needs creep in, due to the wear of tools and fittings, to elasticity and other minute variables. Absolute uniformity, therefore, is impossible of attainment. Commercial or practical uniformity is, however, readily secured. But in proportion as results approximate to exact and absolute results does the cost of production increase. Hence there are *limits* set to the degrees of accuracy which are considered desirable in different classes of work, and the pieces in any given class of manufacture may be allowed to vary from precise dimensions within these *limits of tolerance.* But these limits also are embodied in *limit gauges*, larger and smaller than absolute sizes, and the work has to pass the test of these gauges before it can be sent to the assemblers. Boys, girls, or unskilled youths do this gauging, just as much of the work of the automatics is done by unskilled labour. Often gauging is absolutely automatic in itself, a set of pins, say, being moved along a slot, the sides of which are not parallel. Those pins which fall through the slot between two predetermined stages are within the limits of tolerance. But most gauging has to be done with the gauge in one hand and the piece in the other, yet the test is made in an instant. Then the pieces pass to the assemblers. The subject of gauges and other instruments of measurement is treated in the course on Tools.

Continued

RATIO AND PROPORTION

Definitions. Properties of Proportionals. Continued Proportion. Variation, Direct and Inverse

Group 21
MATHEMATICS
26

ALGEBRA

continued from page 3523

By HERBERT J. ALLPORT, M.A.

RATIO AND PROPORTION

134. The definition of ratio has already been given in the course on Arithmetic. It was there shown that *ratios* can be expressed as *fractions*, so that $a : b$ and $\frac{a}{b}$ each express the ratio of a to b.

The following definitions may be required.

The ratio $a^2 : b^2$ is called the *duplicate ratio* of $a : b$.

The ratio $a^3 : b^3$ is called the *triplicate ratio* of $a : b$

The ratio $\sqrt{a} : \sqrt{b}$ is called the *sub-duplicate ratio* of $a : b$.

If there be any number of ratios, the ratio of the product of their first terms to the product of their second terms is called the *ratio compounded of the given ratios*. Thus, $ace : bdf$ is the ratio compounded of $a : b$, $c : d$, and $e : f$.

135. Four quantities are said to be *in proportion* when the ratio of the first to the second is equal to the ratio of the third to the fourth. Thus, a, b, c, d are in proportion if $a : b :: c : d$. The first and fourth quantities, a and d, are called the *extremes*, and the second and third, b and c, are called the *means*.

When four quantities are in proportion, the product of the means is equal to the product of the extremes.

For, if $a : b :: c : d$, we have

$$\frac{a}{b} = \frac{c}{d};$$

and, multiplying each fraction by bd, we get

$$ad = bc.$$

Conversely, if $ad = bc$, then a, b, c, d will be in proportion.

For, since $ad = bc$, it follows that

$$\frac{ad}{bd} = \frac{bc}{bd},$$

$$\therefore \frac{a}{b} = \frac{c}{d},$$

so that a, b, c, d are in proportion.

136. In the same way we can show that if $ad = bc$, then $a : c :: b : d$. Now, if $\frac{a}{b} = \frac{c}{d}$, it is clear that $\frac{b}{a} = \frac{d}{c}$, or $b : a :: d : c$.

Hence, when $ad = bc$, we have the four following proportions,

$$a : b :: c : d,$$
$$b : a :: d : c,$$
$$a : c :: b : d,$$
$$c : a :: d : b;$$

and, when any one of these proportions is true, we know that the other three are true.

137. Continued Proportion. Quantities are in *continued proportion* when the ratios of the first to the second, the second to the third, the third to the fourth, etc., are all equal. Thus, if a, b, c, d, ... are in continued proportion, then,

$$\frac{a}{b} = \frac{b}{c} = \frac{c}{d} = \ldots.$$

If *three* quantities are in continued proportion, the second is called a *mean proportional* between the other two; the third is called a *third proportional* to the first two.

Thus, if $a : b :: b : c$, then b is a mean proportional between a and c; and c is a third proportional to a and b.

138. If $a : b :: b : c$, then $b^2 = ac$ [Art. **135**]; or $b = \sqrt{ac}$.

Hence, *the mean proportional between two quantities is the square root of their product.*

Again, since

$$\frac{a}{b} = \frac{b}{c},$$

by multiplying each fraction by $\frac{a}{b}$ we get

$$\frac{a}{b} \times \frac{a}{b} = \frac{b}{c} \times \frac{a}{b};$$

or

$$\frac{a^2}{b^2} = \frac{a}{c}.$$

Therefore,

$$a : c :: a^2 : b^2.$$

Hence, *when three quantities are in continued proportion, the first is to the third in the duplicate ratio of the first to the second.*

139. Many problems in proportion are easily solved by using the following important result:

If any number of ratios $\frac{a}{b}$, $\frac{c}{d}$, $\frac{e}{f}$, *etc., are equal to one another, then each of them is equal to the ratio* $\frac{pa + qc + re + \ldots}{pb + qd + rf + \ldots}$,

where p, q, r ... have any given values.

For, let each of the given ratios be equal to k, so that

$$\frac{a}{b} = \frac{c}{d} = \frac{e}{f} = \ldots = k.$$

Then $a = bk$, $c = dk$, $e = fk$, and so on.

Therefore,

$$pa + qc + re + \ldots = pbk + qdk + rfk + \ldots$$
$$= k(pb + qd + rf + \ldots).$$

Hence,

$$\frac{pa + qc + re + \ldots}{pb + qd + rf + \ldots} = k = \frac{a}{b} = \frac{c}{d} = \ldots.$$

Example. If

$$\frac{cy + bz}{p} = \frac{az + cx}{q} = \frac{bx + ay}{r},$$

prove that

$$\frac{x}{a(-ap + bq + cr)} = \frac{y}{b(ap - bq + cr)} = \frac{z}{c(ap + bq - cr)}.$$

Notice how the expression $-ap + bq + cr$ is formed from the denominators of the given fractions, by taking $-a$ times the first denominator, b times the second, and c times the third. By the result just proved, we know that the given fractions are each equal to a fraction with denominator $-ap + bq + cr$ and whose numerator is formed in the same way as the denominator, *viz.*, by taking $-a$ times the first numerator, b times the second, and c times the third.

Hence the given fractions are each equal to

$$\frac{-a(cy+bz)+b(az+cx)+c(bx+ay)}{-ap+bq+cr}=\frac{2bcx}{-ap+bq+cr},$$

by collecting terms in the numerator.

In exactly the same way we can show that each of the given fractions is equal to

$$\frac{2cay}{ap-bq+cr}, \text{ and also to } \frac{2abz}{ap+bq-cr}.$$

Therefore these three expressions must be equal to one another. On dividing each of them by $2abc$ we obtain the required result, *viz.*,

$$\frac{x}{a(-ap+bq+cr)}=\frac{y}{b(ap-bq+cr)}=\frac{z}{c(ap+bq-cr)}.$$

140. The method used in Art. **139** of putting each of a number of equal ratios equal to a single letter, k, can always be followed in such cases as the following.

Example. If $a : b :: c : d$, prove that

$$a : a+c :: a+b : a+b+c+d.$$

Let $\quad \frac{a}{b}=\frac{c}{d}=k.$

Then, $\quad a = bk$ and $c = dk$.

$$\therefore \frac{a}{a+c}=\frac{bk}{bk+dk}=\frac{b}{b+d},$$

and

$$\frac{a+b}{a+b+c+d}=\frac{bk+b}{b(k+1)+d(k+1)}=\frac{b(k+1)}{(b+d)(k+1)}=\frac{b}{b+d}.$$

Thus,

$$\frac{a}{a+c} \text{ and } \frac{a+b}{a+b+c+d}$$

are each equal to $\quad \frac{b}{b+d}.$

Therefore,

$$a : a+c :: a+b : a+b+c+d.$$

VARIATION

141. Consider an article sold at a fixed price, say, 6d. per yard. It is evident that if we double the number of yards we double the total cost; if we take half the number of yards we make the cost amount to half its former value, and so on. When two quantities are related in the way that the number of yards and the cost are here related, so that any two values of the one quantity are in the same ratio to one another as the corresponding values of the other quantity, then the one quantity is said to *vary as* the other quantity.

The words "varies as" are denoted by the symbol $\propto$, so that "a varies as b" is written "$a \propto b$", and means that the ratio $a : b$ has always the same value.

Denoting this constant value by k, we have $\frac{a}{b} = k$, and therefore the value of k can be found when we know one set of corresponding values of a and b.

Example. If a varies as b, and a is 2 when b is 15, what is a when b is 9?

Since $a \propto b$, we have $a = kb$, k being constant. Therefore, since $a = 2$ when $b = 15$, it follows that $2 = 15k$, or $k = \frac{2}{15}$.

Hence, when $b = 9$ we have

$$a = 9 \times \frac{2}{15} = 1\tfrac{1}{5} \text{ } \underline{Ans.}$$

142. One quantity is said to *vary inversely* as another when the first varies as the reciprocal [Examples **30**, No. **2**] of the other.

Thus, a varies inversely as b, when $a \propto \frac{1}{b}$, so that $a = \frac{k}{b}$, where k is constant.

One quantity is said to vary as two others *jointly* when it varies as their product.

Thus, a varies as b and c jointly when $a \propto bc$.

One quantity is said to vary *directly as second and inversely as a third* when its ratio to the product of the second and the reciprocal of the third is constant.

Thus, a varies directly as b and inversely as c if $a : b \times \frac{1}{c}$ is constant, *i.e.*, if $a = \frac{kb}{c}$, where k is constant.

As in Article **141**, the constant can always be found when one set of corresponding values of the quantities is known.

Example. The volume of a right circular cone varies jointly as the height and the square of the radius of the base. The volume of a cone 14 in. high and having a base of 3 in. radius is 132 cubic in. What is the volume of a cone 9 in. high with a base of $3\frac{1}{2}$ in. radius?

If V = the volume, r = radius of base, and h = height, then $V \propto r^2h$, so that $V = kr^2h$.

Hence, when $V = 132$, $r = 3$, and $h = 14$, we have $132 = k \times 9 \times 14$. Therefore, $k = \frac{22}{21}$, and when $h = 9$ and $r = 3\frac{1}{2}$,

$$V = \frac{22}{21} \times \left(\frac{7}{2}\right)^2 \times 9 \text{ cubic in.}$$

$$= 115\tfrac{1}{2} \text{ cubic in. } \underline{Ans.}$$

Answers to Algebra

EXAMPLES 33

1. $\sqrt{5}$.
2. $23\sqrt{3}$.
3. $5\sqrt[3]{3}$.
4. 26.
5. $\frac{2}{3}$.
6. $\sqrt[6]{243}$.
7. $7\sqrt{10}-3$.
8. $2\sqrt{2}+\sqrt{3}$.
9. $7-\sqrt{3}$.
10. $2\sqrt{3}$.
11. $\pm\frac{\sqrt{5}}{5}$, $\pm\frac{\sqrt{17}}{17}$.
12. $0, \frac{1}{4}$.
13. $\frac{9}{13}$ or $\frac{42}{13}$.

Continued

AUSTRALASIA

New Guinea. Physical Features of Australia. Climate, Plants and Animals. Races. Queensland and New South Wales

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

New Guinea. New Guinea (nearly 300,000 sq. miles) stretches between the islands of the Malay archipelago and Australia. Much of it is mountainous, peaks in the Owen Stanley and Bismarck ranges rising to at least 13,000 ft. or 14,000 ft. There are many large rivers, of which the Kaiserin Augusta in the north, and the Fly in the south, are the largest. The northern part of New Guinea has rain at all seasons, but most in northern winter months with the northern monsoon, and is covered with dense tropical forests. Little of the interior, however, has yet been explored. The south has less rain, and this falls chiefly during the northern summer months, when the southern monsoon blows. The vegetation here is open forest, with many eucalyptus and mimosa trees.

Politically, the island is divided between Britain, Germany and Holland. Port Moresby is the chief place in British New Guinea.

AUSTRALIA

The Australian Commonwealth (3,000,000 sq. miles), consists of the continent-island of Australia, with the neighbouring island of Tasmania (26,000 sq. miles). It includes the States of Queensland, New South Wales, Victoria and Tasmania in the east, South Australia in the centre, and West Australia in the west.

Seas, Gulfs and Islands. Australia lies to the south of the islands of the Malay Archipelago, from which it is separated by the Timor and Arafura Seas, and to the south of New Guinea, from which it is separated by Torres Strait. Its western shores are washed by the Indian Ocean, its eastern by the Pacific. The shape of Australia is compact, with few peninsulas and gulfs. Let us look out in a map Cambridge Gulf in the north-west, the great Gulf of Carpentaria, enclosed by the peninsulas of Arnhem Land and Cape York in the north, and on the south coast Encounter Bay, Spencer Gulf, and the Great Australian Bight. Notice how few islands lie off the coast, the only considerable one being Tasmania, a detached fragment of the continent, separated from the mainland by Bass Strait, above whose waters rise small islands. Though lacking in gulfs, Australia has many inlets, which form excellent harbours. Among them are Port Jackson, which forms Sydney Harbour, one of the finest in the world, and Port Philip, the harbour of Melbourne.

Mountains and Rivers. The highest land in Australia forms the eastern highlands, which, under various names, stretch along the east coast of the continent, and are continued in Tasmania. These highlands, generally called the Great Dividing Range, are highest in the south-east, where the Kosciusko group reaches 7,350 ft. To the west of this the highlands are known as the Australian Alps, and north they are known as the Blue Mountains, the Liverpool Range, etc. These long formed a barrier to expansion from the coast to the interior.

The most formidable barrier to exploration was the Blue Mountains behind Sydney. Expedition after expedition was unsuccessful in attempting to find a route across them. "Between the ranges lie yawning chasms, deep-winding gorges, and frightful precipices. Narrow, gloomy, and profound, these stupendous rifts are enclosed between gigantic walls of sandstone rock, sometimes receding from, sometimes frightfully overhanging, the dark bed of the ravine, and its black, silent eddies or foaming torrents. Everywhere the descent into the deep abyss is full of danger, and the issue almost impracticable." At last routes were found, and the railway is now carried across this formidable barrier.

Rivers of the Eastern Highlands. The eastern highlands lie near the coast, and descend more or less steeply to it. Under such conditions, no long east-flowing rivers can be formed. Look out the Burdekin, Fitzroy, Brisbane and Hunter.

The rivers from the western slopes of the northern part of these highlands carry little water, and lose themselves in the dry interior, except after rains, when they flow to Lake Eyre. The largest is Cooper's Creek. The higher, better-watered, southern part gives rise to the only considerable river of the continent, the Murray-Darling. The more northerly waters are gathered up by the Darling, which flows south-west to its confluence with the Murray, which has gathered up the rivers of the southern highlands, the most considerable being the Lachlan and the Murrumbidgee. The main stream of the Murray comes from the Australian Alps, issuing from the mountains, like all the rivers of this part of the system, in a profound gorge, which is known as the Gate of the Murray. The plains surrounding the Murray and its tributaries form the Riverina district, which affords excellent pasture.

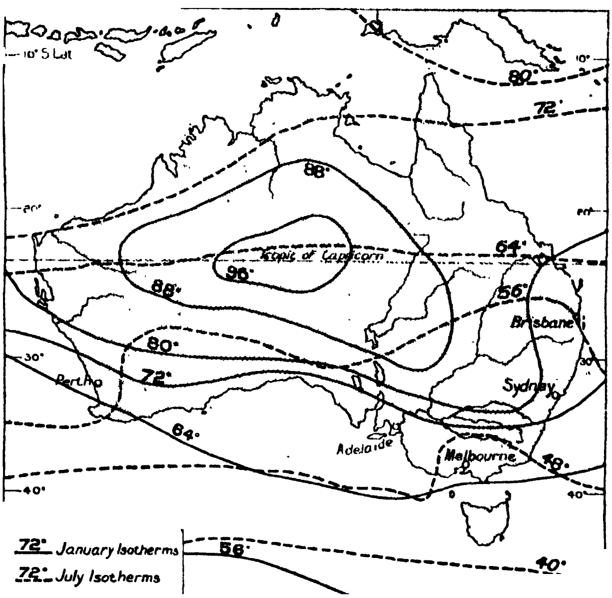
The Central Depression and Western Plateau. West of the Murray, which widens at its mouth to Lake Alexandrina, rises the Flinders Range. West of this is a depression which extends across the continent from the Gulf of Carpentaria, the submerged northern part of it, to Spencer Gulf in the south. The rest of the continent is a low plateau, highest round the margin. The rivers shown in maps are, for the most part, dry channels, except

after rains. The Swan River in the south-west should be noticed.

Climate. If we look at any map of the world, we see that the greater part of Australia is in the same latitudes as South Africa. We also notice that Australia is extremely broad from west to east, and that its general elevation is low and uniform, both favouring a dry climate.

Australia is almost bisected by the Tropic of Capricorn, which crosses it at its broadest part. A very large part of the continent, therefore, has the hot summers and warm winters of tropical lands. The summer solstice coincides with the earth's position in perihelion, when the sun is 1,500,000 miles nearer the earth than at the summer solstice of the Northern Hemisphere. For this reason, and also as a consequence of the absence of a protective covering of vegetation, very high temperatures are recorded in the interior of the continent, where the ground is sometimes so heated, that a match falling on it ignites. Only in the extreme south is the climate temperate, but with warmer summers and winters than our own.

The north and north-west coasts are in the monsoon region of wet summers and dry winters. The eastern highlands condense the winds from the sea and provide a fairly abundant rainfall for the east coast at all seasons, but most in summer. Parts of the south-east and south-west have a moderate rainfall, which is of the Mediterranean type, and falls in winter. The interior of the continent is for the most part an almost rainless desert. Tasmania has rain at all seasons, and differs little in climate from the Channel Islands.



134. ISOTHERMS OF AUSTRALIA

Vegetation. Australia seems to have been cut off from the rest of the Old World very early, and its plants and animals are in many ways exceptional. The trees are evergreen, and suit the hot, dry climate. The tough, leathery leaves are set sideways, presenting their edges and not their surfaces to the sun's rays, thus greatly reducing evaporation. This makes them very shadeless, but as a compensation allows grass to grow where it would otherwise be impossible. The trees grow tall and straight, and stand well apart. The commonest is the eucalyptus, or gum tree, the species of which are very numerous. Many shed their bark annually, and the long, dead strips fluttering in the wind give a weird appearance to the landscape. In the drier regions many trees possess water-storing properties, as in the other arid regions of the world.

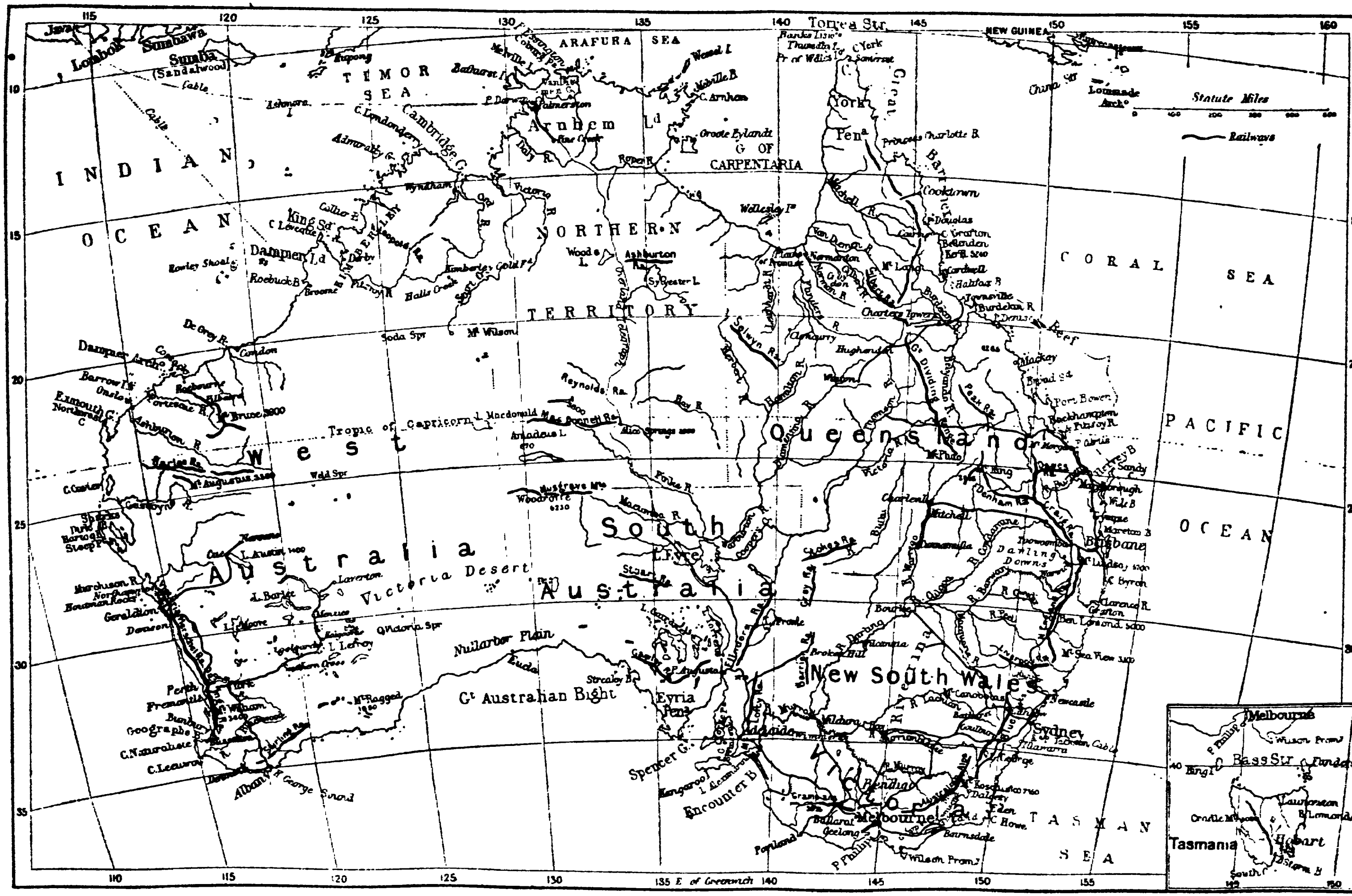
Drought-resisting Plants. The hot, wet, northern tropical regions are covered with tropical forests, with such trees as screw pines, palms, bamboos and mangroves along the coasts. On the drier western margin the forests open out and pass into savanas. The trees diminish in height, and grass or dwarf bushes known as scrub predominate. Of these the commonest are the dense brigalow scrub, the mulga scrub—a sharp, spiny plant very difficult to penetrate, the dreaded spinifex or porcupine grass—whose hard, sharp-pointed leaves, resembling groups of bayonets, inflict cruel wounds, and the salt bush, which covers vast areas of Eastern Australia. All these are drought-resisting plants. Towards the interior even this hardy vegetation disappears and the country becomes a desert.

The east coast is well wooded in the wetter part, various species of eucalyptus predominating. Beyond the Divide the woods pass into grassy downs, scrub and desert. Hardier even than the eucalyptus are the acacias, or wattles, of which numerous species occur.

In the regions of winter rains in Victoria and Western Australia are found two valuable species of eucalyptus, the jarrah and the karri, both hard, durable woods in great demand.

Animal Life. Some curious types of animals are found in Australia. Many are marsupials, which bring forth their young prematurely, to complete their development in the mother's pouch. The kangaroo and the opossum are the most familiar. Other creatures combine the characteristics of reptiles and mammals. The numerous species of birds include the emu, cassowary, lyre-bird, etc. The domesticated animals of Europe have been introduced, and sheep are extremely numerous. The rabbit has become a pest, and starves out sheep by eating up the grass.

Occupations and Population. Australia suffers from two drawbacks—drought and scanty population. The population is



135. MAP OF AUSTRALIA

mainly confined to the coast, and chiefly to the State capitals, especially Sydney and Melbourne.

The exploitation of tropical Australia is rendered difficult by the question of labour. It is not a white man's country, but the introduction of indentured coloured labour is open to grave objections. In Victoria and South Australia wheat is cultivated; and many fruits, especially the vine in the regions of winter rain, come to perfection. As a permanent occupation sheep and cattle breeding will probably always be more profitable than agriculture. Gold mining is extremely important. Enormous sums have been spent in Queensland and other parts of Australia in sinking deep artesian wells to the water-bearing strata, in order to render irrigation possible. Manufacturers are protected by a heavy tariff, but the great stimulus to development, a large home market, is yet wanting.

Races. The aboriginal inhabitants are dying out, and the bulk of the population is of British descent. The aborigines were at a low level of culture, subsisting on the produce of the forests and grass lands, and practising hardly any arts. There is a strong Australian opposition to the immigration of the yellow races, who have secured a precarious footing along the northern coasts. Here, again, an ample population would be a better safeguard than legislative enactments.

QUEENSLAND

Queensland (668,000 sq. miles), is a distinctively tropical colony. The Dividing Range recedes from the coast, giving Queensland navigable east-flowing rivers, whose alluvial lands receive abundant rains from the Pacific. The lands round the Gulf of Carpentaria receive less rain, while the interior is dry.

The Forests of Queensland. The coastal lands of Eastern Queensland were originally densely forested; but with the advance of settlement forests are rapidly disappearing. Sawmills have sprung up in all directions, and in the forest clearings maize, tobacco, sugar and cotton are planted. Coffee has been introduced into the scrub lands of Northern Queensland. An immense variety of fruits can be grown, including the coconut and date palm, the banana, which grows wild, the pineapple, orange, lemon, mango, and many others.

In the Dividing Range the forests remain in their original magnificence. "Centuries old, and towering 200 ft. above you, their topmost branches massed with orchids and lichens, rise the huge, russet-brown columns of the bunyas, the ringed, majestic heights of the pine, and the smooth white pillars of the beech, 100 ft. without a limb. Festoons of brilliant creepers and the thick cordage of the scrub vine swing overhead. At times you pass down avenues of white and yellow orchids, past beds of arum lilies, and between dark-green walls of scrub myrtle, or through a miniature forest of tree ferns. Here the moss-covered trunk of some fallen cedar giant shows amidst a rambling mass of wild raspberry bushes; there a huge Moreton Bay fig-tree spreads a leafy shade, its hollow trunk a network of grey cables, inside which a man can climb for 40 ft."

The Darling Downs. West of the Divide lie the grasslands of Queensland. The richest portion is known as the Darling Downs. This is a fertile and well-watered plain, some 70 miles by 30, surrounded by mountains whose streams have covered the Downs with fertile alluvial black soil. At present it is mainly a pastoral and fruit-growing region, but mixed farming and co-operative dairy industries are developing. Large areas are being sown with wheat, maize, and lucerne, and as settlement advances the Darling Downs will supply wheat, cereals, potatoes, and malting barley, as well as butter, cheese, bacon and fruit. The pastoral products of these and the other grasslands—wool, hides, meat, tallow—are of great value. There is a large export trade in frozen meat, and along the east coast are many freezing works, boiling down works, preserving works, and chilled meat stores.

Mining Industries of Queensland. The mineral wealth of Queensland consists of gold, silver, copper, tin and, in fact, most metals, and many precious stones, such as sapphires. Among many famous gold mines Mount Morgan may be mentioned. Originally bought for £1 an acre, it has paid nearly £5,000,000 in dividends. Charters Towers has yielded over £14,000,000 since 1872.

Artesian Wells. The western part of Queensland is dry, but in recent years it has been found possible to obtain water by sinking deep artesian wells. Up to June, 1902, nearly 950 such wells had been sunk, the deepest of which was over 5,000 ft. while several others exceeded 4,000 ft. Many hundreds of millions of gallons are thus obtained daily, so that a country which a few years ago could not be settled is "now traversed for miles by the lines of rushes which follow the overflowing waters as they meander for miles over the downs, led in channels formed by huge ploughs made for the purpose"

Towns of Queensland. The towns are chiefly along the coast, opposite breaks in the Great Barrier Reef, which skirts the coast. Brisbane, in South Queensland, the capital, is the outlet for the rich Darling Downs region, in which are situated Toowomba and Warwick. Other busy towns are Maryborough, near a sugar, gold, and fruit-producing region; Rockhampton, the chief place in Central Queensland, the outlet for wool and other pastoral produce, and for the gold of Mount Morgan; Mackay, a sugar town; Townsville, the principal port of North Queensland, connected by rail with Charters Towers and other goldfields; and Cairns, in a district growing rice, sugar, coffee, cacao and other tropical produce.

NEW SOUTH WALES

New South Wales (310,000 sq. miles) is the oldest Australian colony. The climate is sub-tropical in the north, while the difference between winter and summer temperatures is not great in the east. The south is temperate.

136. SOUTH-EAST AUSTRALIA, SHOWING PRODUCTS

In the interior, where the heat of summer is intense, the range of temperature is much greater. The rainfall of the east coast is generally sufficient, but west of the Dividing Range it becomes very scanty, and long periods of drought are common.

The Dividing Range. This is from 3,000 ft. to 7,000 ft. high, and fronts the coast steeply at a distance of from 30 to 120 miles. It culminates in Mount Townsend, in the Kosciusko group, which just rises above the snow line, and secures to the Murray a permanent flow. The coastal belt is fertile and crossed by many small rivers, all liable to flood after rain. West of the Dividing Range lie pastoral regions drained by the fan-like tributaries of the Murray and Darling, many of which are empty in the dry season, and flood the country after heavy rains. This region passes gradually into the desert, on the margin of which the camel has been introduced for transport purposes.

Resources of the Colony. About one-fourth of the colony is wooded, and the forests, which are mainly composed of various species of eucalyptus, produce some beautiful cabinet woods. There are many sawmills in the forest area.

Agriculture is carried on in the better watered east, and is growing in the Riverina district. Wheat and maize are the chief cereals, the former producing flour of superfine quality. The brewing industry is developing. Sugar is cultivated in the hotter northern part of the colony. The orange is the chief fruit grown. In the drier west, agriculture is difficult, but in the irrigated districts various fodder crops are raised.

The minerals of New South Wales are valuable. Gold is widely distributed. Silver and silver-lead are abundant round Broken Hill in the west. Coal is mined round Newcastle, Illawarra, and Lithgow, where iron is smelted. Opals are found in some districts, though they are not of the finest quality.

The great resource of New South Wales is the pastoral industry. In 1901 the colony contained 21,000,000 sheep, the merino breed

predominating. Where herbage is poor the runs have to be very large, but the productive power is enormously increased when irrigation from rivers or artesian wells can be carried out. Rabbits are a great scourge, and rabbit-proof fences are erected at great expense in the pastoral lands. The products of the pastoral industry are wool, hides, leather and meat. Meat preserving, boiling down, and wool-washing establishments are numerous. Bourke and Wilcannia are important pastoral centres.

Drought in Australia. A vivid account has lately been written of the horrors of an Australian drought. "Sunrise comes with a fiery red glow, and a scorching wind. After a hasty breakfast washed down by milkless tea, the pastoralist throws himself into the saddle and rides to the big station tanks to superintend the work. Round the shrunken pool of yellow water stands a row of sheep, unable from sheer weariness to extricate themselves from the mud into which they have rushed in their eagerness to drink. The owner looks at the bleating animals, mere skeletons covered by wool and hide, with a dull wonder that they have lived so long. He rides on. On all sides are skeletons and decaying carcasses. Not a blade of grass is to be seen anywhere, nothing but the scanty black-green foliage of the gums, and in the distance the grey, dusty mulga-scrub. He heads for the scrub, crossing the creek bed, now dry and choked with dust. Men are cutting down the mulga, the only food the station affords to the starving sheep. The animals eat it, but not eagerly, even though they are starving, for it is tough and uninviting. The next visit is to the stud flock, once the pride of the station. From a deep water-hole a man is pumping water into troughs, while another is opening bags of chaff. This is hand feeding and an expensive business. Every sheep costs 6d. a day to feed, for the chaff has to be brought hundreds of miles by boat and train, and last of all by team or camel train. The sun climbs higher, and the feeble sheep creep into the shade of the gum trees. Men set about removing the hides and wool of those that have recently died. The choking wind sweeps across the sun-baked land."

Towns of New South Wales. Sydney, the capital, has now eclipsed its former rival Melbourne. It is the terminus of many important steamer routes both from east and west. Its harbour on Port Jackson is one of the finest in the world. "One might live in Sydney a lifetime and then not know every arm and nook of Port Jackson. Each of its inlets is, in a way, a reproduction of the main harbour." The city is built in red and yellow sandstone on the heights round the bay, and presents a fine appearance from the sea. Newcastle is the second town and the principal seaport north of Sydney. Goulburn is an important centre in the south. Bathurst, 150 miles west of Sydney, is the centre of an agricultural, pastoral, and gold-mining district. Many other towns are on the road to prosperity, but at present population is too much concentrated in the capital, Sydney.

VICTORIA

Victoria (88,000 sq. miles), though the smallest, is the most densely populated of the Australian Colonies. It occupies the extreme south-east of the Continent, and has many good harbours, of which the finest is Port Phillip, which forms Melbourne harbour.

Victoria is crossed from east to west by the Australian Alps, rising to over 6,000 ft., a continuation of the Dividing Range. The mountains are forested, and contain many giant eucalyptus trees, some of which exceed 400 ft. in height. Fan palms, tree ferns, and acacias are also common. The southern slopes are drained by short rivers, which cross the fertile Gippsland district to the sea. The northern slopes are drained to the Murray. West of about 145° E. the rivers do not reach the Murray, but dry up or end in salt lakes or swamps. This forms the Wimmera-Mildura district, the poorest part of the colony. Much of this region is covered with mallee scrub, interspersed with the salt bush, and occasionally with good pasture grass.

The climate of Victoria is temperate, with hotter summers than our own, and winters cool enough for an occasional touch of frost, which disappears as soon as the sun is up. The rainfall of the coast is about the same as in Kent, but in the Wimmera district it becomes very scanty. It is everywhere irregular, and seasons of drought alternate with disastrous floods.

Products of Victoria. The leading occupation of Victoria is sheep farming, the wool produced being the finest in the world. The merino sheep has been introduced from Spain, where the climate is not dissimilar. The wool is longer, softer, and more lustrous than any other. Other pastoral products are hides, meat and dairy produce. The dairy industries are now adopting co-operative methods, as in Denmark and Switzerland, and large quantities of butter are consigned to the European market.

Next to wool ranks gold, most of which is minted at Melbourne. Bendigo and Ballarat are famous centres. At Bendigo is the deepest gold mine in the world (3,350 ft.), and several others are carried down to 3,000 ft.

The agriculture of Victoria is rapidly developing. The dry, warm climate suits wheat, which is increasingly grown. The yield is small, but the flour milled from it is of exceptionally fine quality. Fruit growing is important, and apple orchards are numerous. The warm climate, with winter rains, resembles that of the Mediterranean, and the vine is grown with great success. Some wine and light grape brandies are now made.

Towns of Victoria. Melbourne, the capital, on Port Phillip, is the rival of Sydney, and the seventh city in size in the British Empire. With its suburbs, of which Williamstown is the most important, it covers an area of 200 sq. miles. The fine harbour of Port Phillip is entered between the Heads, beyond which the Bay opens out like a great inland sea. Geelong, on the western shore, 45 miles from Melbourne, has woollen manufactures. The gold town of Ballarat is the second city in the colony.

Continued

ACIDS, SUGARS & BENZENE

Cyanides. Oxalic, Tartaric, Citric, and Uric Acids. The Carbohydrates: Sugars and Starches. Acetylene and Benzene. Coal-tar Colours

Continued from page 3558

By Dr. C. W. SALEEBY

WE must now consider the classical discovery of Wöhler, made in 1828. This chemist was the discoverer of the cyanates, and this discovery was the starting point of his artificial preparation of *urea*. Wöhler found that when cyanate of potash reacts with sulphate of ammonia there is produced, as might be expected, cyanate of ammonia, having the formula NH_4CNO. (The reader will not be puzzled by this formula. He will recognise in it the ammonia and the oxidised product of prussic acid which we have already called *cyanic acid.*)

But this cyanate of ammonia is not stable as such. The atoms of its molecules undergo almost immediately a re-arrangement within the molecules, producing an isomeric substance none other than urea—which is a characteristic end product of the breaking down of proteids in the living body, and the constitution of which is best represented by the formula $CO\begin{cases}NH_2\\NH_2\end{cases}$.

Urea, or Carbamide. The strict chemical name for urea is *carbamide*, a name which suggests its constitution. Two other processes of its artificial manufacture must be noted besides the process which will have a permanent place in chemical history. There is closely allied to carbonic acid—which is really carbonyl hydroxide $CO(OH)_2$—a gas known as *phosgene* or *carbonyl chloride* $COCl_2$. If this gas interacts with ammonia, urea and hydrochloric acid are produced, $COCl_2 + 2HNH_2 = CO(NH_2)_2 + 2HCl$.

Again, if ammonium carbonate be heated to about 130° C. it loses two molecules of water and yields urea.

But there is a method by which urea is produced naturally and this is of the utmost importance and interest. It is the most characteristic constituent of the secretion of the kidneys in man and the lower animals in general. It is derived from the breaking down of proteids in the body. These may be either proteids of the body or proteids of the food, which have served various purposes, and the last stage of the chemical degradation or simplification of which is represented by urea. About 500 grains of urea leave the body every day when a mixed diet is taken. The quantity falls to about 300 on a vegetable diet and rises to about 800 on an animal diet. If the subject goes without all nitrogenous food—which he can do for only a short time—he still produces about 200 grains of urea in consequence of the breaking down of his proteid or nitrogenous tissues. Urea leaves the body by the agency of the kidneys, but is not produced in those organs. Their function is merely to select it from the blood, and in this respect it may be noted that a certain amount of help is given them by the sweat glands of the skin, which are capable of excreting no negligible proportion of urea when the kidneys are out of order. It is known that the organ which produces urea in the body is the liver, and of the many substances from which the liver forms urea, three may be quoted—ammonium carbonate, ammonium lactate, and ammonium carbamate. These three substances are the chief immediate antecedents of urea.

Relations of Urea. The process by which urea is formed from ammonium carbonate outside of the body suffices to explain the manner in which the liver effects a similar change within the body. We must also note the fashion in which urea is produced from ammonium carbamate. The relations of the body known as *carbamic acid* will be readily seen from the accompanying formulæ:

$$\text{Carbonic Acid} \;..\; CO\begin{cases}OH\\OH\end{cases}$$

$$\text{Carbamic Acid} \;..\; CO\begin{cases}OH\\NH_2\end{cases}$$

$$\text{Carbamide (Urea)} \; CO\begin{cases}NH_2\\NH_2\end{cases}$$

It is, in short, a half-way house between carbonic acid and urea, or carbamide. The carbamate of ammonia has the formula of carbamic acid plus the formula of ammonia. The reader will see, if he writes this formula out, that the abstraction of one molecule of water from it will leave a molecule having the formula of urea. Thus, in both these cases the action of the liver is one of dehydration; and both of these actions can be produced outside the body by heat, since ammonium carbamate, like the carbonate, yields urea and water when heated. Ordinary smelling salts, by the way, consists more of ammonium carbamate than of its nominal constituent ammonium carbonate.

Urea is a Base. Its reactions with acids prove that urea is a base, for it readily forms a number of salts. One of these, the nitrate of urea, is utilised on account of its relative insolubility. If the secretion of the kidney be evaporated to a syrupy consistence, and then nitric acid added, the nitrate of urea is formed. This can be decomposed by barium carbonate, yielding barium nitrate, carbonic acid and urea, which is separated from the barium salt by means of alcohol. Urea forms white prismatic crystals which are very readily soluble in alcohol and in water. It is so soluble and diffusible that its removal from the body is an extremely easy matter. In these physical characters urea markedly differs from another

substance which we are shortly to study, *uric acid*, which is the characteristic end product of the chemical degradation within the body of a particular kind of proteids which are known as the *nucleo-proteids*.

Other Reactions of Urea. Just as urea and water are produced by the decomposition of ammonium carbonate, so, under other conditions, urea and water can be made to form ammonium carbonate. This synthesis is also effected by the vital activity of an omnipresent microbe which is known as the *bacillus ureæ*.

The estimation of the quantity of urea produced by the body every day is a matter of the first importance in a very large number of diseases, and is usually accomplished by the estimation of the volume of nitrogen given off from a given quantity of urine when the urea in it is decomposed by the addition of a solution of hypobromite of sodium. This salt has the formula $NaOBr$, and is a powerful oxidising agent. Carbonic acid is formed, but is absorbed by the free alkali in the hypobromite solution, nitrogen alone being evolved and measured as soon as it has cooled.

Some New Organic Acids. There remain a few important organic acids derived from the hydrocarbons that we must briefly discuss. They have varying claims to attention, the first being of great importance as a poison, while others are very valuable constituents of various fruits, and help to account for their dietetic value. Tartaric acid, which belongs to this group, has already been discussed in part.

Oxalic Acid. We have already seen that all the carbon acids contain the group carboxyl, $COOH$. The formula of oxalic acid is simply twice that of carboxyl. It may be prepared, for commercial purposes, in many ways, and occurs naturally in certain plants in the form of its salts. Thus, the oxalate of lime is contained in rhubarb, while the hydrogen potassium salt occurs in sorrel, and is thus known as *salts of sorrel*. Oxalic acid is largely used for cleaning straw hats, so that in some parts of the country it is known as *bonnet acid*. We have already referred to it as an acid which exercises poisonous actions independently of the actions common to all the strong acids. Thus, a soluble salt of the acid is almost as dangerous as the acid itself. It acts upon the central nervous system, causing drowsiness and stupor. The essential part of the treatment in cases of oxalic acid poisoning, which is lamentably common, is not merely to neutralise it, but to form *an insoluble salt*, and this can be done by the administration of any preparation of lime. Clever and well-trained policemen have not infrequently saved life in these cases by scraping whitewash from a wall and administering it to the patient. Salts of sorrel is often used for the purposes of a poison, and is practically equivalent in its action to oxalic acid itself. Broken-down crystals of oxalic acid are sometimes sold by mistake as Epsom salts or sulphate of magnesium.

Malic Acid. This is another form of organic acid which naturally occurs in various forms of vegetable life, and especially in apples, from the Latin name of which (*Malum*) its name is derived. Like lactic acid, malic acid contains an asymmetrical carbon atom—an important term already defined—and therefore rotates the plane of a ray of polarised light.

The natural acid is left-handed, and an artificial acid can be prepared which is optically inactive, consisting of a mixture of right and left-handed acids.

Tartrates. When discussing the work of Pasteur we said all that need be said about tartaric acid, but some of its salts are worthy of mention. The hydrogen potassium salt is known as *cream of tartar*. A double salt of potassium and sodium is known as *Rochelle salt*. Cream of tartar is deposited on the sides of wine casks in the crude form known as *argol*. It is used in medicine, having the characteristic properties of salts. Rochelle salt is produced by the addition of cream of tartar to a hot solution of sodium carbonate, and is similarly employed in medicine. It is one of the chief ingredients of a seidlitz powder. (The reader must not confuse *argol*, the salt, *argon*, the gaseous element, and *Algol*, the famous double star.)

Tartar Emetic. Much more important in some ways is the salt known as *tartar emetic*, or *tartarated antimony*, which may be somewhat loosely described as a tartrate of potassium and antimony. It is prepared by the interaction of cream of tartar and antimonious oxide. In former days tartar emetic was very largely used in medicine, but we recognise nowadays that, since it contains antimony, it is a protoplasmic poison. Its administration causes extreme depression, and, despite its name, it should never on any account be used as an emetic. Indeed, it should be abolished altogether from the Pharmacopœia. In cases of acute poisoning by this dangerous salt, the symptoms of which are very similar to those of arsenical poisoning, the patient's strength must be conserved in every possible way, and tannic acid, or strong tea containing tannic acid, forms one of the best antidotes.

Citric Acid. Citric acid has already been mentioned as a typical organic acid which, for reasons we have explained, actually increases the alkalinity of the blood. Some of its many sources have already been named. It crystallises in rhombic prisms, is readily soluble in water, is the most pleasant to the taste of the organic acids, and has a calcium salt which is noteworthy in that it is less soluble in hot water than in cold. Citric acid may be taken freely in beverages without any fear that it will attack the enamel of the teeth. Citric acid is also deservedly famous as the specific preventative of the disease called *scurvy* or *scorbutus*, which was once the sailor's curse. At times this disease has threatened the safety of the British navy, but forty years ago the carriage of lime-juice—containing citric acid—on board ship was made compulsory, and now the disease has become extremely rare. It is interesting to note that doctors are quite at a loss to explain the disease, though there is none more easily cured.

Nowadays they are much more familiar with infantile scurvy. This disease very commonly occurs among children fed exclusively upon sterilised milk. Indeed, a baby fed on nothing but sterilised milk will develop scurvy. The mere addition of a teaspoonful of orange-juice—containing citric acid—to the daily diet of such a baby will cure or prevent the disease. Probably the most important factor in the relative success of Arctic exploration in more recent years has been the prevention of scurvy among the crews by the simple expedient of carrying lime-juice, the essential constituent of which is citric acid.

Uric Acid. The last acid of this group that we need consider is known as *uric acid*, and has the empirical formula $C_5H_4N_4O_3$. It is a subsidiary constituent of the secretion of the kidney in mammals, including man. In birds and reptiles, however, the kidney secretion of which is solid, urea scarcely occurs at all, and is replaced by urates. About ten grains of uric acid are daily secreted by man, not in the form of acid, but as its sodium salt. It is exclusively derived from the class of proteids known as *nucleo-proteids*, which have this name because they are characteristic constituents of the nuclei of living cells. No quantity of a simple proteid, such as white of egg, in the diet will increase the secretion of uric acid. On the other hand, the characteristic proteid of milk is a nucleo-proteid, and allied bodies are contained in meat in general. Furthermore, tea and coffee are capable of yielding uric acid. Now, there is a modern and popular doctrine that most human ills are due to the occurrence of uric acid in excessive quantity in the blood, and there is some small percentage of truth, at any rate, in this. Organic chemistry has so far advanced, however, that in cases where "uric-acidæmia" is really to blame, the diet can be so modified that scarcely any uric acid is derivable from it. Such a diet will be vegetable, and will include eggs and milk, which are of no practical importance as yielders of uric acid. The point to recognise is that uric acid is produced only by a certain group of proteids—besides malt liquors—and that if these be omitted, any quantity of other proteids may be taken. It is safe to say that, on the ground of excessive production of uric acid, and on other grounds, we must judge as very excessive the amount of meat consumed by the overwhelming majority of prosperous people in this country. Among the most characteristic constituents of meat, found most abundantly in meat extracts, is sarcin. This, when oxidised, yields another body called *xanthin*. The characteristic alkaloids of tea, coffee and cocoa are derived from xanthin. Extracts of meat, tea and coffee have their use—and unfortunately their abuse—as stimulants. They are destitute of any food value, and are therefore worse than useless where stimulation is not required, since the first, at least, leads to the formation of uric acid.

The Carbohydrates. We must now consider the last group of paraffin derivatives—the *carbohydrates*. The term has already been defined, and when we discussed formaldehyde reference was made to the theoretical fashion in which we may imagine the carbohydrates to be synthesised in plants—which, until recently, were their sole source. Lately, however, the artificial synthesis of certain carbohydrates has been added to the achievements of synthetic chemistry, and the noteworthy fact is, that it is formaldehyde from which the chemist starts. When a solution of formaldehyde in water is shaken with milk of lime and filtered, there is produced a substance called *formose*, which is itself none other than a carbohydrate or mixture of carbohydrates, and has the same empirical formula as the typical sugar, $C_6H_{12}O_6$.

We cannot here discuss the remarkable work which has been done upon the constitution and chemical relations of the sugars and their derivatives. Chemists have found, however, that these carbohydrates must really be looked upon as complex examples of other paraffin derivatives, which we have already studied. Some of them are really alcohols, some are aldehydes, some are ketones, and so on.

Dextrose or Glucose. This very important and typical sugar has the empirical formula $C_6H_{12}O_6$. It occurs in many fruits, and is produced in the blood in large quantities in the disease known as *diabetes*. In these cases it is derived from various carbohydrates of the diet, or, failing them, even from proteids, well proving the extreme complexity of the molecular constitution of these last. Glucose is also produced outside the body from other carbohydrates, such as starch, which has the formula $C_6H_{10}O_5$. If this be boiled with a dilute acid, each molecule of starch takes up one molecule of water, yielding dextrose. Cane sugar also yields dextrose if it be boiled with a dilute acid. Its formula is $C_{12}H_{22}O_{11}$, and this, plus a molecule of water, yields two molecules of $C_6H_{12}O_6$. As we shall see, however, they are not both molecules of dextrose, though they have the same formula, for the product is found to consist of two sugars, one dextro-rotatory—*dextrose*—and the other lævo-rotatory—*lævulose*. The net action of the mixture, however, is lævo-rotatory, whereas the original cane sugar was dextro-rotatory, and thus the cane sugar is said to have undergone the process of *inversion*.

Lævulose is found to accompany dextrose in fruit and in honey. Both of these sugars are readily decomposed by yeast, yielding alcohol and carbonic acid, as we have seen.

Tests for Glucose. The presence of glucose in the secretion of the kidney indicates its excessive presence in the blood, and is a matter of extreme importance. Thus chemical tests for glucose have been very carefully investigated. The most familiar of these consists in the employment of what is called "Fehling's solution." This consists essentially of cupric oxide, CuO, which is reduced, under the influence of glucose, into cuprous oxide, Cu_2O, forming a red precipitate. Various other bodies besides glucose, however, may effect this reduction, and, therefore, other tests are necessary. One of the best is the fermentation test, which is carried out by the use of yeast ferment.

Cane Sugar and Milk Sugar. We have already seen the formula of cane sugar or *saccharose*—the characteristic sugar of the sugar-cane, the beet, and other plants. This extremely valuable food is not utilised in the body as such, but as glucose—the final form in which the body utilises all its carbohydrates. Cane sugar is not capable of fermentation until it has been hydrolysed to form dextrose and lævulose. Reference has already been made to *lactose* or milk sugar, which has the same formula as cane sugar. Its sweetness is not very marked. It is less soluble in water than most sugars, and it is very resistent to fermentation, being thus specially fitted for milk.

Starch and Cellulose. If we examine a potato through the microscope, we find that it consists of a large number of granules of starch bounded by a tough wall. The contents of the granules are often known as *granulose*, while their walls consist of *cellulose*. Both have the empirical formula $(C_6H_{10}O_5)_n$. Cellulose is entirely indigestible by any ferment in the body, and thus the value of boiling a potato consists in the splitting of the starch granules so that the digestive juices can act upon the starch which they contain. Starch is the pre-eminent form in which vegetable life stores its energy. The "n" in its empirical formula doubtless corresponds to a very high number, and there are very many substances which have similar formulæ and may be regarded as modifications of starch. Among these is *dextrin* or British gum, a yellow powder which can be produced by heating starch to 200° C. It is soluble in water, and can be chemically distinguished from starch by the fact that it does not yield, with tincture of iodine, that intense blue colour which anyone can see for himself who drops the minutest trace of the tincture on his collar. The animal body also contains a substance called *glycogen*, which has the same empirical formula as starch, and is sometimes called *animal starch*. It is produced from glucose, and stored up in very large quantities in the liver, which can hydrolyse it again into glucose and serve it out in the latter form to the blood as a source of energy, according to need.

Digestion of Starch by Hydrolysis. Starch itself is readily converted into sugar outside the body by boiling with dilute acids, and also by the action of a ferment called *diastase* which, as we have seen, is found in the barley grain and in other germinating seeds. The starch first changes into dextrin and then into dextrose. A similar ferment occurs in the saliva, where it is known as *ptyalin*. An essential part of proper treatment of the food consists in due mastication, which means due admixture of the food with the saliva. Thus swallowed, the starch of the food undergoes change by hydrolysis into sugar in the stomach for twenty minutes or half an hour, before the process is arrested by secretion of hydrochloric acid by the stomach wall. The pancreas or sweetbread also produces a very much more powerful ferment, called *amylopsin*, which is poured into the bowel and converts all the starch hitherto undigested into dextrose, in which form it is absorbed.

We have here discussed only the most important of the large group of substances which may be classed as the carbohydrates and their derivatives. A point necessary to be emphasised is that we must not allow ourselves to be deceived by the name carbohydrate, nor by the apparent simplicity of the empirical formulæ of these bodies. Even if we consider formaldehyde itself, which has the ideal empirical formula of a carbohydrate, we find that its constitutional formula is HCOH, and that it is thus in no sense whatever a hydrate of carbon. Perhaps the best value that we can attach to this name to-day is the warrant which it appears to afford for the very probable theory that the beginning of the synthesis of the carbohydrates by the plant is to be found in the union in its leaf of the carbon which that leaf has dissociated from carbonic acid of the atmosphere with water which has been sucked up by its roots from the soil.

A New Group. We have now devoted all the available space to the paraffins and their countless derivatives. We now turn to another large group of bodies which are sharply distinguished from the paraffins by the condition of their carbon atoms. In the typical paraffin, which is methane, we find that, so to speak, all the four-handed carbon atoms are holding something. This is true of all the paraffins and their derivatives. But we must now describe a number of paraffins which are described as *unsaturated*, in order to indicate the fact that all the hands of their carbon atoms are *not entirely* occupied. If, for instance, we take the second paraffin, *ethane*, we see that the two atoms of carbon are united to one another by means of a single hand on the part of each, the other three hands of each being occupied with a hydrogen atom. But there is another substance called *ethylene*, which also contains two carbon atoms, but which has the graphic formula $H_2C=CH_2$. Here we find that the carbon atoms are *doubly linked* to one another, but, as ethane has proved for us, the second link is superfluous; one would suffice, and thus it is that these bodies are capable of combining with other atoms directly, thus becoming saturated, as the phrase goes; they are therefore known as *unsaturated compounds*.

The name applied to ethylene and the other members of its series is the *olefines*, and we can assign to them a general formula as we did in the case of paraffins. It is C_nH_{2n}. If the reader does not remember the general formula of the paraffins, so that he can mentally compare it with this, he should look it up.

Various Olefines. The first of the olefines should have the formula CH_2, but does not exist by itself. It is called *methylene*. We have already stated the formula of the second, *ethylene*, often known as *olefiant gas*. If we adopt measures which seem likely to result in the formation of methylene, we always find that its molecules pair up, so to speak, so that we get ethylene instead. This body may be prepared in many ways, as, for instance, the interaction of ethyl iodide and caustic soda. This results in the formation of ethylene, sodium iodide, and

water. The reader should write the equation. It is also produced by the distillation of ordinary alcohol with excess of sulphuric acid. Hydrogen ethyl sulphate, as we have already seen, is formed, and if this undergoes decomposition, sulphuric acid and ethylene result, thus:

$$HC_2H_5SO_4 = H_2SO_4 + C_2H_4.$$

Olefiant gas is also produced in the destructive distillation of wood, coal, resins and fats, its production being due to the decomposition of the methane evolved from these bodies. It is one of the most important constituents of coal gas, being very inflammable, and burning with a luminous flame. (It is worth noting, however, that recent study of the luminosity of flames shows that this depends, much more largely than used to be supposed, upon the incandescence of solid particles within them.)

Characters of Olefiant Gas. Ethylene is a colourless, pleasant-smelling gas, very slightly soluble in water, but somewhat more so in alcohol and ether. Under the influence of cold and pressure it becomes liquefied, and its subsequent evaporation from this state is largely used for the production of extreme degrees of cold. The words *olefine* and *olefiant* mean oil-making, and ethylene was called olefiant gas because, when it becomes saturated by the addition of two atoms of chlorine, yielding $C_2H_4Cl_2$, or ethylene chloride, the product is an oily liquid; but our previous study of the oils will have shown the reader that, despite their names, the olefines have nothing to do with them. The other olefines, such as propylene and butylene, need not here be discussed. In general, the olefines may be converted into paraffins by the action of nascent hydrogen, as we should expect. This soon catches on, so to speak, to the scarcely occupied hands of the doubly linked carbon atoms. As in the case of the paraffins, we find that as we pass up the series of olefines successive members are found to be liquid, and, later, solid.

Oleic Acid. On account of its relation to the olefines, we may here mention oleic acid, $C_{17}H_{33}COOH$, which has already been referred to, in our discussion of the fats, but which, as we saw, is not a fatty acid, being related rather to the olefines than to the paraffins. This acid exists, in combination with glycerine, in most fats and oils, especially the non-drying oils. The acid itself is a soft solid below the temperature of 14° C. We have already seen that its sodium and potassium salts are the chief constituents of soaps. The oleate of lead used to be used in surgery as *lead plaster*—sometimes called *lead soap*. It can readily be produced by rubbing litharge or PbO and olive oil together in a mortar, or by boiling the oxide with water and olive oil. Olive oil is an impure oleate of glyceryl, and the products of the reaction are lead oleate and glycerine.

Acetylene. There remains only one other gas which we need study before we pass on to an entirely new series of organic compounds; this is the gas known as *acetylene* or *ethine*. It has the formula C_2H_2, and may be prepared in various ways. The elements unite directly if carbon be raised to a very high temperature in the presence of hydrogen. This discovery was made by Berthelot, in the year 1859, and is of historic interest since it formed the first stage in his artificial synthesis of alcohol. Acetylene is also produced by an incomplete combustion of hydrocarbons, as, for instance, methane. Part of the hydrogen of the methane is oxidised to water, and acetylene results. In practice, the acetylene is absorbed by an ammoniacal solution of cuprous chloride, forming a somewhat remarkable explosive compound of a red colour known as *copper acetylene*.

The gas may also be produced by the interaction of chloroform and metallic sodium. The reader should write out the equation showing how two molecules of chloroform and six atoms of sodium yield common salt and acetylene. The empirical formula of this substance throws no light upon its extremely interesting constitution. Its two carbon atoms must be regarded as united with one another by means of not one hand apiece, as in the case of ethane, nor two hands apiece, as in the case of ethylene, but three hands apiece. This triple bond is the characteristic of acetylene and its allies.

Characters of Acetylene. Ethine is an evil-smelling, colourless gas, and is a normal constituent, in varying degrees, of coal gas. It burns with an extremely luminous flame, which endows it with great value as an illuminant. Unfortunately it cannot be stored with safety in its liquid form, which is obtained by cold, or pressure, or both, since it is extremely liable to explode.

The various means of making acetylene which we have quoted have all been superseded in commerce by another process, which was first discovered by Wöhler. This chemist was the first maker of the compound known as the *carbide of calcium*, and he found that this compound was decomposed by water with the formation of lime and acetylene. Carbide of calcium is nowadays formed in the electric furnace by the direct union of the purest possible lime and coke. It is a crystalline solid, stable in dry air, but decomposed by the smallest quantities of moisture. The equation for the decomposition is simplicity itself:

$$CaC_2 + H_2O = C_2H_2 + CaO.$$

Needless to say, the lime unites with more water to form calcium hydrate.

Acetylene itself has definite poisonous properties, but some of the impurities which constantly occur in it, such as carbon monoxide and phosphoretted hydrogen, are worse. Great improvements have lately been made in the process of purifying acetylene before its consumption. Great improvement has also been made in the manner of its combustion. When the right kind of burner is employed, this gas yields a flame which, for brilliance and beauty, is equalled by none of its competitors. Every reader is familiar with it as an illuminant for the head-lights of motor-cars.

The Aromatic Group. We now turn from the paraffins, the olefines, and their derivatives, to an entirely new series of hydrocarbons, the

typical representative of which is *benzene*. Adopting the widest possible classification, we may say that the bodies we have hitherto been discussing are of the fatty group, but that benzene and its allies belong to the *aromatic* group. The empirical formula of benzene is C_6H_6, and we may write this in a more generalised form, C_nH_{2n-6}. Hydrocarbons of this series, with their derivatives, belong to the aromatic group, a large number of them being obtained from aromatic substances, such as balsams and resins. The leading characteristic of this group, as a whole, is the relative stability of its compounds as compared with those of the fatty group. Here, however, we may quote Professor Meldola, regarding the relation that exists between these two groups, and the quotation will show us the propriety of concluding our study of the fatty group with acetylene :

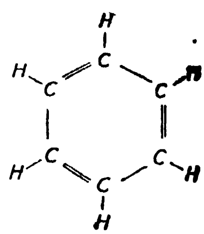
"The division here made between fatty and aromatic substances must not be regarded as one having a sharply defined boundary line. In point of fact, the two series merge into one another, and compounds belonging to one group can be transformed into compounds of the other. Thus, benzene, the typical hydrocarbon of the aromatic group, can be formed directly from ethine or acetylene, a hydrocarbon of the fatty group, by the polymerisation effected by heat :

$$\underset{\text{Ethine}}{3C_2H_2} = \underset{\text{Benzene."}}{C_6H_6.}$$

The Characters of Benzene. Let us first consider the sources and characters of benzene, and then let us see whether its chemical reactions will enable us to write its graphic formula. It is often known as *benzol*, and the name is derived from the gum resin known as *benzoin*, derived from a tropical tree, and the source of the famous antiseptic medicament known as Friar's Balsam. Commercial benzoin, however, is obtained from coal-tar, which is, indeed, the principal source of most of the members of this series. Coal-tar is the product left behind when coal is distilled so as to produce coal-gas. This coal-tar or coal-tar oil is of a very complex composition. It is first of all neutralised with soda and with a weak acid, so that any acids or bases present in it may be removed. The oil is then distilled, or fractionally distilled, certain portions of it coming over at low temperatures and others at higher temperatures. The "light oil" which distils over first consists mainly of benzene. This is a mobile, colourless liquid with a characteristic but not offensive odour, lighter than water, boiling at about 80° C. and freezing at 5° C. It is very nearly insoluble in water. In accordance with the generalisation already laid down, it is extremely stable, and can scarcely be oxidised. It burns with a fairly brilliant flame. Under certain conditions it can be made to take up six atoms of hydrogen, yielding a body the formula of which is C_6H_{12}. Or it may take up six atoms of chlorine, under the influence of light, giving a body with the formula $C_6H_6Cl_6$, or certain of its hydrogen atoms may be replaced by halogen atoms, as, for instance, in di-chloro benzene, $C_6H_4Cl_2$.

Graphic Formula of Benzene. All these reactions, and a host besides, including the formation of benzene from acetylene—as we have seen—by a sort of condensation in its molecules when they pass through a red-hot tube, led the chemist Kekulé to construct a graphic formula of benzene, the truth of which is now generally accepted by chemists, and the evidence in support of which might be extended over many pages. This celebrated formula is known as the *benzene ring*, the theory being that the six carbon atoms are united with one another in a closed ring or chain, on the outside of which, so to speak, are attached the six hydrogen atoms, one to each atom of carbon. If the reader draws such a formula for himself without any further hints from us, he will detect a flaw in it, and he will do us a favour if he tries to find out this flaw for himself before reading any further. Let him remember the valency of carbon—and consider.

The Necessary Correction. Plainly, it will be necessary for us to suppose that each carbon atom is in a different relation to its two carbon neighbours. To its neighbour on the one side it is united by only one hand, but to its neighbour on the other side by two hands, while the fourth hand is occupied, obviously, with an atom of hydrogen. Thus, the formula, as the reader originally wrote it out, can be corrected by simply doubling every other line between the carbon atoms, thus :



This discovery of the constitution of the benzene molecule occupies an important place in the history of organic chemistry. We may here quote, in conclusion, one simple illustration of the applicability of this formula to the facts. Let us take, for instance, benzene hexa-chloride, $C_6H_6Cl_6$, and see how its formula must be written. Plainly, all we need to do is to suppress the double bonds in the carbon ring, leaving each of the six atoms united to its fellows on each side by one hand only, and thus we shall see that hands are available for the addition of a chlorine atom beside the hydrogen atom all the way round. We may note the parallelism between this and ethylene chloride. Our graphic formula answers other requirements with equal satisfaction, and in all subsequent study of the aromatic compounds we shall take its truth for granted.

Practical Uses of Benzene. We have outlined very briefly the pure chemistry of benzene, and have seen how great its interest is. We must now consider its practical uses, which we can divide under three headings. In the first place, it is a very valuable solvent for a large number of organic compounds ; secondly, it is the starting-point of the great industry concerned with the manufacture of dyes from coal tar ; thirdly, it is the source of a host of derivatives which we may call the *benzene derivatives* or *aromatic compounds*, and which

are of great practical utility. As may readily be imagined, the number of different kinds of molecules that may be derived from one so complex as that of benzene is illimitable. We may choose two of the simplest possible examples, and then consider the product. Just as in the case of methane we find it possible to replace a hydrogen atom by hydroxyl, so we find it possible in the case of benzene. The molecule is a symmetrical one, so that it matters not which hydrogen atom we require it to replace. The formula of the body just produced will, of course, be C_6H_5OH. Its technical name is *phenol*, the group C_6H_5 being known as *phenyl*, while its common name is *carbolic acid*. To take another instance, let us substitute the now familiar group carboxyl for a hydrogen atom, giving us the formula C_6H_5COOH. The body thus obtained is known as *benzoic acid*. Lastly, let us replace one of the hydrogen atoms with the group NH_2. We shall then have a body with the formula $C_6H_5NH_2$, chemically known as *phenylamine*, and commonly as *aniline*.

Carbolic Acid. Of these bodies, perhaps the most important and interesting is carbolic acid or phenol. In practice it is obtained by the treatment of heavy coal-ta. oil with soda or potash. If an acid be then added, the carbolate of soda is decomposed and the carbolic acid comes over. We call this body an acid, but the reader will understand that it may also be regarded as an alcohol. It certainly is an acid in that it forms salts, but it does not redden litmus paper. We have just as good a title to call it *phenyl alcohol* as carbolic acid. The commercial product is extremely liable to impurities which commonly give it a reddish colour, and many of these are more poisonous and more irritant than carbolic acid itself—the use of cheap carbolic acid in hospitals being thus an unsatisfactory kind of economy. Pure carbolic acid crystallises in fine colourless needles; it melts at 35° C., and boils at 187° C. It is highly soluble in alcohol, ether, and oils, but is only very slightly soluble in water. The solution commonly known as "one in twenty," is almost the strongest that can be obtained. On the other hand, one part of water with ten of carbolic acid produces what is practically a pure liquid carbolic acid. Even in its aqueous solution this substance coagulates albumin, and it exercises a very powerful caustic action when concentrated, even though it is not acid enough to redden litmus paper.

Uses of Carbolic Acid. We owe to the late Professor Calvert, whose name survives in the famous firm of that name, the possibility of the manufacture of carbolic acid in a pure form fit for use in medicine and surgery. A crude carbolic acid is also largely used for preserving railway sleepers, its value depending upon its antiseptic properties. Carbolic acid is also used as a source of dyes, though it is of less importance in this respect than aniline. Picric acid, for instance, is a brilliant yellow body produced by the addition of small quantities of nitric acid to carbolic acid. Lately, dilute solutions of picric acid have been found very valuable in the treatment of burns.

Among the convenient tests for carbolic acid may be named the violet colour, gradually turning brown, which it yields on the addition of the minutest quantity of a dilute solution of ferric chloride; and the white precipitate, soluble in excess of phenol, which it yields with bromine water.

Carbolic acid is a protoplasmic poison, directly interfering with all life. It probably acts in virtue of its coagulation of albumin. It will always be the classical antiseptic, since it was employed by Lord Lister in the beginning; but though it is still used in enormous quantities, it is very far from ideal. It is relatively weak, a solution of at least 2 per cent. in strength being necessary to kill the average microbe. Dissolved in oil, this acid entirely loses its antiseptic properties; carbolic oil should therefore be dismissed from surgical service. The drug is very readily absorbed by the skin—even the unbroken skin—provided, of course, that it be applied in a very dilute solution. This property makes it very valuable in the treatment of such disorders as a whitlow, since we can imagine the carbolic acid, so to speak, chasing the microbes under the skin and killing them.

Toxicology of Carbolic Acid. It has already been noted that this acid acts as a poison independently of its local caustic properties, thus resembling oxalic acid. Certainly the acid may kill, in consequence of its action upon the stomach, and in cases of poisoning it is desirable to neutralise it with chalk on the spot, or to dilute it with white of egg, so as to avert its local action; but it has to be remembered that any soluble carbolate circulating in the blood will surely kill in consequence of its action upon the nervous system. It is necessary, therefore, to consider further the history of carbolic acid after absorption, and to see whether there are any chemical means by which the consequences of its absorption may be neutralised. The question is a very important one to the surgeon, because he uses carbolic acid so extensively, and because it is necessary for him to be able to control immediately any undue consequences of its absorption. But it is also of great importance to the public in general, because the modern and wide employment of carbolic acid as an antiseptic and disinfectant has lately made it an extremely frequent cause of death by poisoning. Indeed, this dangerous acid is so easily obtained, on any of a hundred pretexts, that it has lately come to rank third among the poisons that most frequently cause death in this country.

The True Antidote. On close study it is found, then, that carbolic acid entering the blood undergoes oxidation in part into various innocent substances. The whole of the rest of it is converted into sulpho-carbolates, sulpho-carbolic acid being obtainable outside the body by the addition of sulphuric acid to carbolic acid. These sulpho-carbolates are quite innocent, and, therefore, so long as

there remains any free sulphate in the blood, the absorption of carbolic acid is free from any danger. The dose of carbolic acid which causes death by its action after absorption is one which is so great that all the sulphates in the blood are used up, with the consequence that carbolates themselves are allowed to circulate.

This discovery is of the greatest practical importance. In the first place, it provides us with a test of safety. It is a simple matter to ascertain whether a patient who has been treated with carbolic acid externally or internally is excreting free sulphates by his kidneys. If free sulphates are absent, then danger is at hand. If they are present, the treatment may be continued. Secondly, we are now provided with a true chemical antidote to carbolic acid even after absorption into the blood. The whole danger lies in the using up of the available sulphates. We must therefore provide more sulphates. Any reader of this paragraph may have the opportunity of saving a life thus threatened—suicidally or otherwise—by the administration of, say, an ounce of magnesium sulphate—the Epsom salts which can be bought at any chemist's shop—dissolved in a tumblerful of water. The most rapid means of treatment consists in the injection into a vein of a sterile solution of half an ounce or more of sodium sulphate.

Nitro-substitution Compounds. The action of nitric acid, or a mixture of nitric and sulphuric acids, upon benzene and its allies is to form nitro-substitution compounds, of which the simplest is known as *nitro-benzene*, and has the formula $C_6H_5NO_2$. This is a yellow liquid with a pleasant smell closely resembling that of oil of bitter almonds which has the formula C_6H_5COH. Nitro-benzene is sometimes substituted for oil of bitter almonds in the manufacture of confectionery, and has thus caused death. There is no objection, however, to its use in perfumery. Di-nitro-benzenes are known in which two hydrogen atoms have been replaced by the nitro-group.

Picric acid, to which we have already referred, is a nitro-substitution compound of carbolic acid, its technical name being *tri-nitro-phenol*, three nitro groups having been substituted for three hydrogen atoms of the phenol. Its salts are called *picrates*.

Aniline. The body which has the formula $C_6H_5NH_2$—much better written thus than as C_6H_7N—is often known as *phenylamine* or *amido-benzene*. The name is derived from *anil*, the Portuguese word for indigo, since, in 1840, it was shown that this body could be produced by the action of caustic potash on indigo. It is a heavy, oily liquid, colourless, and has an unpleasant smell. It produces a greasy stain upon paper, but the oil is so volatile that this soon disappears. It burns readily and is oxidised on exposure to the atmosphere, turning a deep brown. It is a poison, and it has been shown that the poisonous action of nitro-benzene also is due to its reduction in the stomach with the formation of aniline.

As long ago as 1835 it was known that aniline produced a fine blue colour when treated with calcium chloride. But it was not until considerably later that this property of the body was turned to practical use. We shall shortly discuss the subject, because it affords an extremely significant lesson of national importance.

The Manufacture of Aniline. A substance of such great commercial importance has to be manufactured as cheaply as possible on the large scale, and the method employed depends upon the production of nitro-benzene, a body which we have already studied. This, having been produced from coal-tar, is reduced by nascent hydrogen which is evolved by the interaction of iron filings and dilute acetic acid. This is one of those processes in which certain of the reagents can be used over and over again. In this case ferrous acetate is produced, and then ferric acetate, nascent hydrogen being meanwhile evolved, and then the ferric salt is converted into hydroxide and free acetic acid again. From this last the aniline is distilled over. The equation representing its formation is

$$C_6H_5NO_2 + 6H = C_6H_5NH_2 + 2H_2O.$$

The commercial product, however, is not pure aniline, but a mixture of aniline with an allied body called *toluidine*, which is closely allied to it. The presence of the toluidine or toluidines is necessary for the production of colours from the aniline.

The Work of Perkin. The famous name in the history of this subject is that of Sir W. H. Perkin, F.R.S., the jubilee of whose great discovery has recently been celebrated in this country. It was in 1856 that Sir William was led to study the effect of mixing the sulphate of aniline with bichromate of potash in equivalent proportions. After some hours, when the reaction is complete, the black precipitate which is formed is washed and purified, and is found to consist essentially of the dye best known as *mauve*. Sir William Perkin patented this process at the age of 18, and it was in commercial employment in 1857. From that year dates the foundation of the coal-tar colour industry. Sir William met with many difficulties, but conquered them all. He discovered later a method by which he could synthesise the red dye known as *alizarin* in a fashion commercially practicable. This country long benefited by his work on this subject. In 1862 it was prophesied by Professor Hofmann, Perkin's first teacher, that "instead of disbursing her annual millions for these substances, England will, beyond question, at no distant day become herself the greatest colour-producing country in the world; nay, by the very strangest of revolutions, she may ere long send her coal-derived blues to indigo-growing India, her distilled crimson to cochineal-producing Mexico, and her fossil substitutes for quercitron and safflower to China, Japan, and the other countries whence these articles are now derived."

A Lost Industry. Thirty years ago it could be said that Hofmann's predictions were realised, but they are not true to-day. The

practical extinction of the coal-tar colour industry in the land of its birth is the best-known example of an industry lost to a country by sheer carelessness and laziness. Year by year the industry has become more and more important, more and more competent and profitable. Since Perkin turned his attention to pure chemistry, having given this country a start which should have been worth millions of pounds, new coal-tar colours have been discovered with increasing frequency. At the present moment the industry founded by this Englishman is a German industry, and a source of enormous and ever-increasing profit to the enterprising people who believe in science. Incidentally, their vigour has destroyed, or is on the way towards the complete destruction of, certain industries of great importance to our Indian Empire, such as the cultivation of the indigo plant. In this country, the record of which in science is unparalleled in ancient or modern times, and is probably equal on the whole to the entire scientific record of the rest of the world put together, science and commerce are hardly on speaking terms. The manufacturer has a process which yields him profit. If he be a German he is not content therewith—some of the large German firms employing more young trained chemists apiece than are similarly employed in the whole of this country. Thus the German goes on while the Englishman stands still. Sir William had done far more than his share, but since the date—1874—when he turned to other subjects, those who are so deeply indebted to him have done practically nothing. The inevitable consequence followed. The industry went where its profits were earned. It is now a German industry, and Sir William's reflections on this subject in the year 1906, which still finds him hale and vigorous, would probably make remarkably interesting reading.

The Warning of Sir William Huggins. Having drawn the reader's attention to what must surely long remain a classic instance of a national loss thoroughly well deserved, we make no apology for quoting a paragraph, which cannot be too widely read, from a recent presidential address delivered before the Royal Society by one of the greatest men of science now living, Sir William Huggins. Referring to the testimony given by thirteen Fellows of the Royal Society before a recent Committee of the London Technical Board, Sir William says:

"The testimony of these expert witnesses was all but unanimous in showing that one of the most obvious shortcomings affecting our national industries—namely, the relatively small number of suitably trained men possessing the technical knowledge and creative skill needful for the improvement of our chemical, electrical, and engineering industries, must be regarded as a secondary symptom, following upon the smallness of the demand for such men. Further, that this smallness of demand is itself the necessary consequence of a wider and more serious state of things, which is affecting injuriously all our national activities—namely, the absence, speaking generally, of a sufficiently intelligent appreciation on the part of the leaders of the nation, whether as legislators, capitalists, manufacturers, or merchants, of the supreme importance of scientific knowledge and scientific methods, not only for the successful carrying on and improvement of all industrial enterprises, but also, and not less so, for the working out of all national problems whatever, whether of education, of economics, of hygiene, or especially of national defence in the construction of our armaments by sea and by land, and the training of our soldiers and sailors."

A Parallel Case. The text upon which we are now preaching may be illustrated in many ways—one of the most striking being the recent demonstration that an essential factor in the triumph of Japan in the late war was her adherence to the principles of hygiene, prevention of infectious disease; and antiseptic surgery, which the world owes mainly to this country, and which were so scandalously neglected, to the loss of thousands of lives and millions of pounds, in our own late war. But even this example is not quite equal in irony to that afforded by the recent celebration of Perkin's discoveries, while the people among whom the discovery was made and to whom he belongs yearly pay enormous sums to Germany for what are really the products of his brain. It is our earnest hope that the readers of the SELF-EDUCATOR may have cause to regard themselves as fortunate exceptions in respect of that system of education in which the thoughtful mind of Sir William Huggins has discerned the true underlying cause of the nation's failure to appreciate and to profit by the achievements of the individuals whom it is foremost in producing.

Advance in Coal-tar Dyes. And now let us briefly consider the progress of the study of aniline during the last 30 years. An important step in this industry was taken when Hofmann discovered the nature of the coal-tar dye known as aniline red or magenta, which he found to be a salt of the base now known as *rosaniline*, and manufactured from aniline containing certain proportions of toluidine. Hence, there are now obtained rosaniline blues and violets, aniline green, and a certain proportion of what is called *aniline yellow*. These dyes are now used for many other purposes besides dyeing, and their use will steadily extend, for they are, in general, superior on every ground to their natural rivals. Their discovery should be a source of congratulation to the artist and to those who are sensitive to visual beauty, and should give such persons a friendly feeling for chemistry. It is not our business to discuss here the technology of the subject, which is of very great complexity, and which, under the conditions habitual in Germany, undergoes improvement and advance every day.

Continued

Continued from page 3533

BELTING MANUFACTURE

Leathers Suitable for Belting. Cutting, Trimming, Shaving, Building, Splicing, and Joining Belts. Link Belting

By W. S. MURPHY

MANY beltmakers tan and curry the hides for their own use; but their processes differ in no way from ordinary tanning. In general, it may be said that the raw material of the beltmaker is the finished product of the tanner and currier.

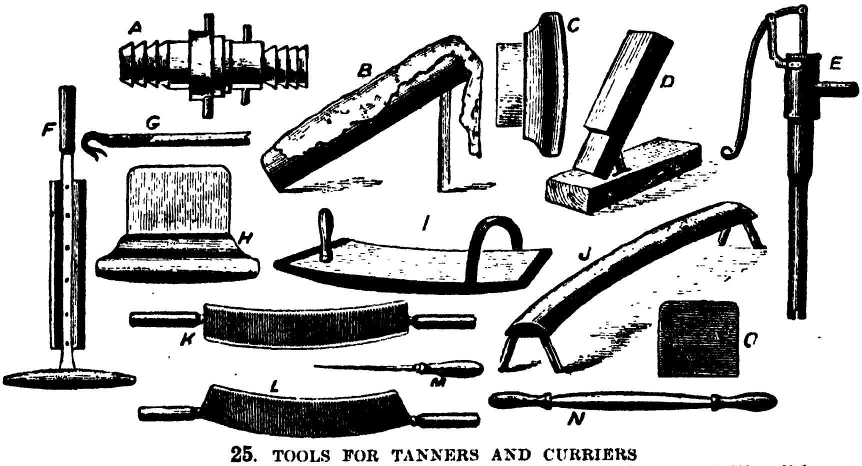
Belt Leather. For the finer and heavier classes of belts, however, special hides are required. Perhaps the best hides for heavy belts are those of Highland cattle, and next come the Shorthorns. From the carcase of a stout Highland bull you can get a hide giving about 1 in. of leather thickness—that is, after epidermis and flesh layer have come off.

Giraffe Hides. Among the hides of wild animals useful for belting are the pelts of the giraffe, the gnu, and the quagga—all abounding in British South Africa. Giraffe leather has great density of fibre, and stands the wear and tear of shifting, twisting, and sudden pulling in a remarkable way.

Rawhide Belts. As shown in the table of tensile strengths [page 3532], the best tannages are chrome, alum, and "rawhide." The last is simply the method of the backwoodsman made into a factory system. After being thoroughly dried by exposure to the air, the hide is soaked in pure water for fifteen days. The hair now comes readily off on the unhairing knife. Next the hide is stretched on frames, and piled one above the other, in a dark, well ventilated shed to dry again. Shaving the flesh side, the curriers break-over and stuff with oil. When seasoned, the hide is ready for being made into belting. We have heard, with some surprise, many tanners praise that method of preparing leather, though, if it were adopted universally, their occupation would be gone. One thing is certain—"rawhide" leather retains all its fibres and gelatinous substance unimpaired, and has all the natural strength and tenacity of the hide.

Beltmakers as Tanners. One reason for so many beltmakers undertaking tanning and currying as well is that overtanned hides are almost useless for belts, and the fault is not easily detected if the tanner chooses to do a little doctoring. The beltmaker's tools [25] for currying are similar to the tools used for tanning leather for other purposes. Overtanning reduces the tensile strength of leather by about one half. It is the interest of the tanner to win the favour of a customer as important as the beltmaker, and he will no doubt do his best; but the beltmaker naturally knows the need of his trade better than the tanner, and can seek out new kinds of hides and methods of tanning with greater probability of hitting the mark.

Complete Belt Factory. Looking at it from the outside, people think of the beltmaking trade as a very small one of limited range; but we have quite a different opinion. On the one hand, the trade extends into the tanning, and on the other it touches on cotton manufacture, indiarubber, and rope-making. We sometimes come upon contracts which cannot be filled by leather belts alone. Cotton belts, or belts of rubber-filled canvas, may be absolutely essential, and must be procured. If the profits of contract are not to be frittered away in paying high prices to other manufacturers for special work—prices to which they are perfectly entitled—the beltmaker must do his own weaving. A complete belt factory, therefore, is not a small undertaking.

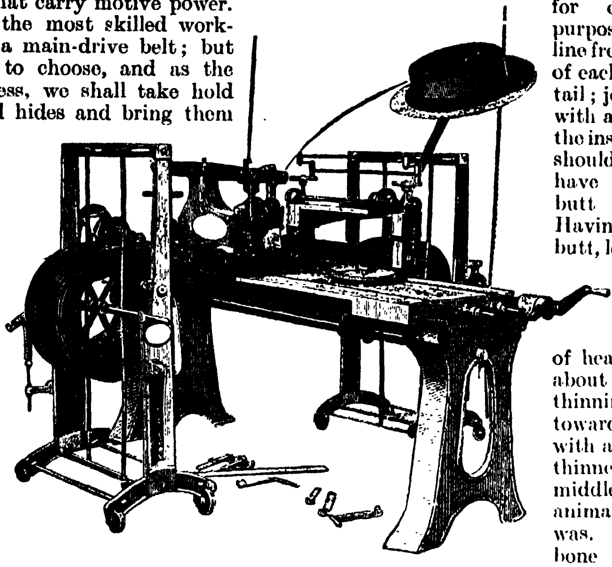


25. TOOLS FOR TANNERS AND CURRIERS

a. Gun-metal union for base pipe *b.* Fleshing, scudding, or unhairing beam *c.* Setting slicker *d.* Shaving beam *e.* Tanners' hand pump *f.* Shaving knife *g.* Pit hook *h.* Whitening or buffing slicker *i.* Graining board *j* Pinning beam *k.* Fleshing knife *l* Fleshing knife for cleaning *m.* Steel for sharpening *h* *n.* Striking pin *o.* Loose whitening or buffing blade for *h*

On the one side, you have the hide sheds, lime pits, tan pits, and currying shops; on the other are the cotton canvas looms, and in the midst are belt-making shops, where these materials are formed into the bands that carry motive power.

Stretching. Only the most skilled workmen are entrusted with a main-drive belt; but as we are at liberty to choose, and as the greater includes the less, we shall take hold of a batch of Highland hides and bring them through to the finished belt. The curriers have brought them to the drying-room, and hung them up; but we must not allow the hides to dry completely. As soon as the wetness has gone, the heavy sheets of leather must be stretched. If the hides are taken in from an outside tan works, they are dry, of course, and must be softened and damped. Take one of the stretching frames and lay it on the bench. In structure the frame is very simple. The sides are strong wooden battens; at top and bottom a pair of screw clamps cross the frame and hold on to the sides by slide joints. In the centre a thick worm-screw runs through holes in the under bars of the clamps. Lay the hide, evenly damped throughout, in the frame, neck to the head and tail to the bottom; screw the clamps firmly down; turn the centre screw till the hide is drawn tight as the head of a drum and tighter. All the hides of the batch must be treated in this way, and then left to dry. Leather shrinks in the drying, and the already stretched hide is drawn still tighter.



26. WIRE SEWING MACHINE FOR BELTING

Rules to be Noted. If the stretching is done properly, very little trouble will arise on that account during the working life of the belt. We need hardly point to the importance of this. Young workers, however, sometimes require the caution that "strength and ignorance" are not the equipment of a beltmaker. You may be gifted with the strength of a young bull, but it is not necessary to exert the whole of it in stretching leather. Some judgment is needed as well. With such an instrument as the stretching frame, a strong man could rack the hide, but that is not the purpose of it. The long lever has been devised to make hard work a little easier. So, too, with the damping and drying; the natural force of shrinkage is called in, not to break the frames, but to lighten the stretcher's labour. Muscles are spared in order to afford brain a chance. Accidents will happen, of course, and even the most careful workman will occasionally hear the rending crash of a drying frame breaking under the strain; but experience quickly enables the worker to understand the stretch required by the average hide.

Cutting the Hide. The sole-leather manufacturer rejects a considerable portion of the hide, but we reject a good deal more. In fact, only about one-third of the hide is useful for our present purpose. Draw a line from the middle of each flank at the tail; join these lines with a third across the inside of the fore shoulder, and you have sketched the butt of the belt. Having cut out the butt, let us see what we have got. It is an almost square piece of heavy leather—about 4 ft. square—thinning slightly toward the sides, with a hard bank of thinness along the middle where the animal's backbone was. This backbone strip should be made the centre of a broad belt if possible, because it is strong and gives the belt a gentle, natural curve inward, hardly perceptible in the finished article, yet secretly effective in aiding the belt to cling to the pulley when working.

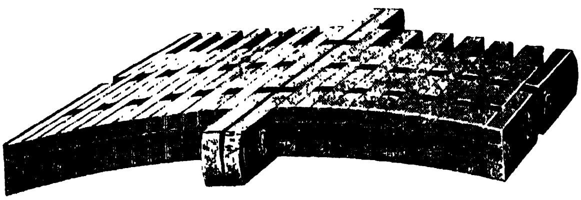
Trimming. In the trimming-room all kinds of cutters are provided. Our tool, however, is a huge guillotine cutting machine. The blade, 5 ft. long, is hung in the cross-beam above the table and between the supporting pillars. By means of a gauge at the side we can measure the breadth of the cut to the thousandth part of an inch. The exact size got, and the clamp screwed down, we set the terrible blade going, and it shears down through the leather with irresistible force. One side trimmed, the other is put in and cut to the size.

Shaving. In spite of every care, the flesh side of the leather is rough, and, of course, the hide varies a good deal in thickness all over. We can get rid of the roughness and inequality at one time. Cylinder shaving machines have been provided for the purpose. Section after section of our belt, showing every possible variation in relative thickness and roughness, is run into the machine after it has been properly adjusted, and all come out from under the cylinder as alike as so many bullets. Anyone can learn to work the shaving machine. It is a cylinder covered with knives geared above an adjustable roller. Having been set to the proper thickness, the machine carries the leather against the revolving knives, and a surface as smooth as glass is the result. We often hear of the superiority of machine over hand production, and this is certainly a finished piece of

work; but we have seen hand shaving quite as good. A first-class workman will shave a hide as smoothly as any machine yet invented, and his hand is gentler on the leather. The machine is quicker and more reliable; let the mechanic be content with that.

Hand shaving is an accomplishment that never comes amiss to a beltmaker; indeed, a good hand shaver is frequently needed in shops where machinery runs from basement to top flat. Perhaps the best place to learn how to handle the shaving knife is at the whitener's bench in the currying shop. Take the broad-bladed knife, hold the handle with both hands, letting the thumbs grip on the back and the four fingers of each hand rest lightly on the blade. Setting the edge at the proper plane, you curve round with a sweep, reversing the curve at the next stroke. With careful practice a man can learn to shave a dry hide so smoothly that no line of the knife is visible. It is good training for the hand and eye.

Building the Belt. Now we go into the machine shop, and here the practice of beltmakers differs to such a degree that what is right in one shop may be held to be altogether wrong in another. The merest outlines, therefore, are all that can be given. Some beltmakers pride themselves on having invented the machines they use, and the new man in the shop has to learn part of his trade over again. However, it is all in the way of making belts, and the building up of a belt is the same, whatever may be the way of doing it.



27. TULLIS' PATENT FLEXIBLE CENTRE LINK BELT

First, then, having gathered our pieces from the cutters and trimmers, we begin to build up our big belt.

Splicing. The great belts that fly round on the drive of a dynamo of 500 h.p. appear to be one single piece, but we know that is impossible. We have to build those long things up piece by piece, not one piece more than 4 ft. long. The homogeneity of the belt is accomplished by splicing. For instance, take two pieces of leather, pare the ends of both to a thin edge in a slice of about 4 in., put them together, and you will find, if you have done the paring evenly and equally, that the two make no more than the thickness of the rest of the leather. That is splicing or *skiving*. We have a few skiving machines, all of them quite effective. One, the best we have seen, has a slanting table adjustable to any angle, and driven under a fixed blade. On the table the belt-piece is laid, and the blade shaves off a graduated strip, beginning at a thin edge, and rising to the thickness of the belt. To balance the belt, and make all the pieces lie on a level plane, the skiving is cut alternately on flesh and grain side. The two ends of each piece are exactly half the thickness of the belt, extended over a graded surface, and when the two are put together they make exactly the same bulk as the rest of the belt.

Joining. We have many methods of joining the splices together, those most common being thread sewing, wire sewing, lacing, riveting, and cementing. For single belts, the breadth of which is one piece, we prefer cementing. It makes the neatest job, and lasts as well as any.

Many beltmakers have patent cements of their own, the composition of which they jealously keep secret, but many good recipes are the common property of the trade. The following are representative and reliable:

1. Soak in water just sufficient to cover them, for ten hours, equal parts of common glue and isinglass; gradually bring to the boil, adding tannin extract till the whole takes on a ropy consistency. Apply the cement to the freshly spliced surfaces, join, and clamp them firmly together.

2. Gutta-percha dissolved to the consistency of syrup in bisulphide of carbon makes a strong cement. In applying, first fill up the pores of the leather with the mixture cold. Heat the cement, cover both surfaces, join together, and hammer the joint till it has become firm and cold.

3. Mix ten parts of bisulphide of carbon with one of oil and turpentine; put in as much gutta-percha as will make the liquid thick when it has dissolved. When ready, the cement is a slowly flowing mixture. Before applying this cement, however, it is necessary to clear the surface of the leather from grease. Steep a cloth in strong ammonia, lay it on the piece to be joined, and run it over with a hot iron. Coat the cement over both sides of the joint, join, and put under the press.

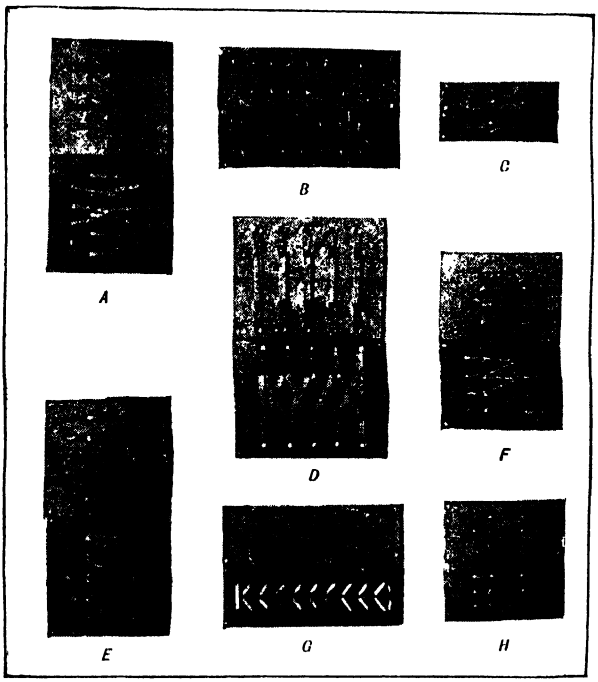
Stitching. All the other methods of joining splicings require that holes be bored in the leather. When sewn on the machine [26], the needle does the perforation in the fittest way. Up till very recently, the idea of applying a sewing machine to a belt wider than six inches was regarded as preposterous; but now we see machines joining belts nearly thirty inches broad. Before stitching, either by hand or machine, it is advisable to channel the course of the sewing, so as to protect the threads from friction

Lacing. If lacing be considered the best way of joining a belt, another point comes into prominence. We ought, rather, to say two points—namely, the piercing of the holes and the pattern thereof [28]. Punching holes is altogether discredited, because the force of the punch bruises the leather round the holes, and drilling is now generally adopted. The holes should be drilled perfectly round, and in a V shape, slightly angled. By adopting this shape, you never have more than one hole in the same line across

the belt. This spreads the lacing over the belt and gives a firm grip.

Riveting. Extra broad belts require to be built together like the sides of a ship, and here, as there, the rivet is the only sure binder. Riveting calls for a system of splicing of its own. Instead of a broad, graduated band, you make a narrow flange, little broader than the rivet-hole. There are many riveting machines in use, and hundreds of different makes of rivets on the market. The ideal rivet is round, with a broad, thin washer. It must always be remembered that the pull of a belt is lengthwise, and corners or points on rivets will break into the leather in spite of the most ingenious safeguards.

Link Belts. Between the swiftly running pulley and the driving belt there is always a cushion of air. In narrow belts this mattered little, but when we began to put on belts six feet up to ten feet broad, the air-cushion became a decided nuisance under certain conditions, notably when swift drives were on. To make a perforated belt was to weaken it enormously. Nature seemed to have put a barrier across the beltmaker's path of progress, saying, "Thus far, and no further." But it occurred to one beltmaker and another — for no one has a monopoly of the idea — that a link or chain belt would solve the difficulty [27]. Moreover, the beltmaker has a lot of offal, that goes into the glue-pot. By adopting the link idea, we at once have a new form of belt and a means of using up our scraps. Scrap leather, it must be said, is good leather, but simply too small for forming a belt out of. The making of link belts is a new and important branch of the trade, and highly interesting.



28. BELT LACING

a. Four-inch belt. Double lacing. Stands highest test of tensile strength *b.* Lap belt lacing *c.* One-inch diamond pattern lacing *d.* Six-inch double lace with full lace *e.* Four-inch belt with narrow lace *f.* Three-inch belt with narrow lace *g.* Herringbone pattern lap lacing *h.* Two-inch double lacing with narrow laces

Making Link Belts. First, the pieces of scrap, of a proper thickness, are put under the die-cutter and cut to size. Next, the pieces are soaked in warm water, and then put under the hydraulic press in a mould. When the pieces come out, they are as hard as iron. Now they are put under the drills, and two rivet-holes bored in each. It is obvious that we can build up any size of belt we like out of these pieces, just as you can make any breadth of chain by putting links together. The method of building up these belts is simple and ingenious. One piece forms the centre, and to each end of this two pieces are riveted. Each of those joined pieces has a rivet-hole free, into which another pair of links can be fixed. The end pieces are half-links, with only one hole, thus giving a flat surface at the finish, and a complete belt.

We have purposely left out of account the numerous kinds of small belts made, because the greater, in this case, includes the less. If you can make a belt for the main drive, the small machine belts will give you no trouble.

Loom Pickers. Before the link belts were thought of, the beltmaker had found a certain kind of outlet for his offal in making engine-washers, loom-pickers, and other wares of that kind. It was for these purposes, indeed, that the die-cutters and hydraulic presses were introduced to a large extent into the belt factory. Loom-pickers require to be light, hard, and of firm consistency. Carefully selected, the leather for the pickers is steeped in oil, cut to shape in the die-cutter, and pressed. The pieces are cemented or riveted together.

Washers. By a process similar, waterproof washers for water engineers of all grades are made, from the rings of the huge hydraulic ram to the washers of the domestic water-tap.

Standing, as the beltmaker does, as a helper of many industries, he sees opportunities of usefulness and profit hidden from other workers in leather. Most of us hold the faith that "There is nothing like leather," but we have not all an equal opportunity of making practical recommendation of our faith.

Continued

Group 25 HEALTH 8	
Continued from page 3602	

Continued from page 3602

BAD FOOD AND GOOD AIR

Milk. Cream. Butter. Cheese. Flour. Bread. Meat. Poultry. Fish. Condiments. Jam. Beverages. Air and its Impurities

By Dr. A. T. SCHOFIELD

WE shall here only touch upon those adulterations connected with our food or drink, and that only with extreme brevity; for we regret to say that the subject is so large and complex that a whole book could be filled with it. The difficulty is to find a single article of commerce that is not liable to adulteration.

Milk. There are three principal ways in which this is adulterated—as a rule, by the milk retailer. Adulteration is not so much practised by the wholesale dealer, for according to the report of the Local Government Board, only 17 per 1,000 samples are condemned in the wholesale trade to 125 per 1,000 in the retail.

These three ways are by adding water, by removing cream, and by adding drugs.

WATER. When water is added, the specific gravity is lowered. That of milk is 1·029; as a rule, some cream is removed at the same time and the specific gravity is thus raised, so that milk can be made very poor, and yet the lactometer will show the right gravity. A further test is needed. The total, which must be found by evaporation, should then be 12 per cent. of milk, of which 3·5 should be fat, leaving 8·5 solids *not fat*. If, then, solids are less than 8·5, water is added. For instance, if there are only 7·0 per cent., then $\frac{100 \times 7}{8·5}$ or 82·35 is really milk, showing 17 per cent. of water has been added, and the use of the lactometer and evaporation together will always detect the double fraud.

CHALK. This is not now added to milk, but carbonate of soda, salt, boracic acid, salicylic acid, annatto, glycerine, formaldehyde, naphthol, starch, germs and dirt are put in it.

Most of these drugs, some of which are powerful irritants, are added to prevent decomposition, and the worst is that each person through whose hands the milk passes may add a little, so that the total amount is serious. For instance, it is not uncommon to find a drachm of boric acid (60 grains) in a gallon of milk; the full medicinal dose of which is 5 to 15 grains.

ANNATTO. This is a yellow colouring matter which makes poor milk and cream look richer.

GLYCERINE. This is detected by the excessive sweetness of the solids.

Perhaps, as a whole, the most deleterious substances added are those which are the result of carelessness rather than intention—filth of every description. We are entering fully into this in dealing with food in infancy, and therefore shall only say that in nearly every case it consists of some form of excreta from farmyard sweepings, in addition to ordinary dirt. The one remedy is to purchase milk only from those dairies which are inspected, and which make a special point of delivering pure milk. We must not name them, and can only say that every householder should be sure that the milk that is used is pure.

Cream and Butter. Cream is often thickened with gelatine and starch, coloured and preserved with drugs. Taste and smell should be guides in testing butter. According to analysis, it is generally sold pure, for out of 4,329 samples examined in London, only 321 were found adulterated. But this report is not wholly reliable; for it is impossible to discriminate margarine adulteration by analysis. In Holland, a very special form of margarine is scientifically prepared, and 10 per cent. of it can be mixed with butter without any fear of evidence that could result in a conviction. *Room-butter* or cream-butter is as special an article in Holland as *biene-honig* (bee honey) is in Switzerland, adulteration being so common.

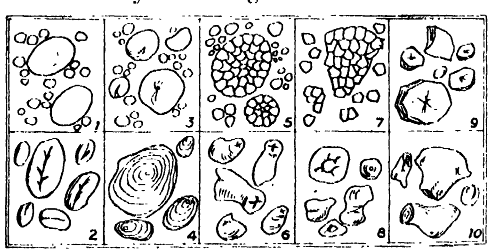
Besides margarine, water is added. Good butter has about 2 ounces of water in the pound; but bad butter, in 16 ounces, has often 6 oz. of water, 1½ oz. of margarine, and ½ oz. of suet and drugs—not a desirable compound. In one pound of butter, 94 grains of boric acid is sometimes used, equal to nearly 10 medicinal doses.

Cheese. Cheese should be moist, with a smooth rind. A rich cheese has bulging sides, a poor milk cheese has straight sides. Cheese is adulterated in many ways; starch is added to increase weight, and margarine may be added to milk cheeses to make them richer.

Flour. Flour is largely adulterated, besides being made from inferior and diseased grain.

Inferior kinds are generally of a bad colour, but by the addition of chlorine and ozonised air these can be made snow white, so that their imperfection is almost impossible of detection.

Fortunately, this diagram shows that each



STARCH GRAINS

1. Wheat Starch 2. Pea Flour 3. Rye Starch 4. Potato Starch 5. Oat Starch 6. Arrowroot Starch 7. Rice Starch 8. Tapioca Starch 9. Maize Starch 10. Sago Starch

variety of starch has a different shaped grain, so that each one can readily be recognised with the microscope. The adulteration, therefore, of

flour with inferior starches (rice, potatoes, etc.) is easily detected. Other flours are similarly adulterated besides wheat flour, such as sago, arrowroot. Arrowroot, being expensive, is extensively adulterated with potato starch; indeed, "English arrowroot" consists entirely of this.

Bread. Bread is adulterated with alum, but not so much so as formerly. If there be over 10 grains in a 4 lb. loaf, there is adulteration. This is readily detected by a solution of haemotoxylin and ammonia, which turns bread pink; but if there be alum, it turns blue.

Meat. Meat, fowl and fish are not, of course, adulterated; but much that is inferior, diseased or stale is still sold. We give, therefore, a few hints to help in securing wholesome food. [See also "A Marketing Guide," HOUSEKEEPING, page 1227.] It is not easy to distinguish the best foreign meat killed in England from home-grown and home-fed beef and mutton. Frozen meat, or, as it is sent now, refrigerated meat (that is, cooled, but not frozen) is quite good and wholesome. The principal difference between it and fresh meat is in the flavour, which is never so good in the case of meat which has been kept on ice. But the difference in price is so great that it is far better for those who are really poor to buy the best foreign meat than any other. To a certain extent, the following remarks apply to this sort of meat, though they are really descriptive of home-killed meat.

Stale or bad meat looks flabby, spongy, and whitish; the eyes of the animal are sunk and the kidneys are bad; the fat is yellow and there is very little of it.

In buying meat, always choose it yourself; see it weighed, and pay for it at the time, and thus save not less than 20 per cent. Deal, if possible, with one respectable butcher; or you may buy the home-killed beef from one, and frozen mutton from another, for frozen mutton is in better condition than frozen beef.

BEEF. Prime ox beef has an open grain, is of a carnation colour, and marbled with streaks of fat. The fat should be white. Cow beef looks paler and the grain is closer. If the meat is dark red and the fat skinny, it is too old. If it rises quickly upon pressure by the thumb, it is prime meat; if not, it is poor.

MUTTON. Prime mutton, if large, is probably Sussex or Scotch; if small, Dartmoor or Welsh. The latter is darker and leaner, the former paler and fatter. The meat should be firm and close-grained, and the more fat, the primer the meat. Good meat does not shrink much in cooking, and does not gape wide open when cut.

VEAL AND LAMB. Never buy very young veal or lamb. Veal should be two months old at least, and the flesh dry, not clammy. Lamb should be small, pale red and fat.

PORK. Pork is best with a thin rind. Buy only from a dealer you can trust, as it is often diseased. The meat should not be flabby or clammy, but the fat hard and the lean nearly white. The pressure of the thumb on the rind should leave a dent or mark.

BACON. Bacon should be fat, clear, and not streaked with yellow. The flesh should adhere closely to the bone.

Poultry. As a rule, fowls and turkeys are very digestible, but ducks and geese, which are fatty, do not suit everyone.

FOWLS. In buying fowls, choose male birds. If young, they have smooth legs and short, soft spurs; the feet bend, the eyes are full and bright. Never buy a fowl turning blue or with stiff feet, and a cock with a sharp spur is too old. Young birds have transparent, unwrinkled skins. Dorking fowls are considered the best.

YOUNG GEESE have yellow feet; old ones have red.

DUCKS should have the breast-bone soft and gristly, and the feathers unformed.

TURKEYS should have a smooth skin and no spur.

Fish. When buying a fish, see that it is short, thick, well made, with bright scales, and stiff and springy to the touch. The gills should be fresh and red, and the belly firm. If the gills are not bright and of a fresh red, the fish is uneatable. Be sure and clean fish as soon as ever you can, and especially remove the livers, as if they are left in, the oil from the liver will soak into the flesh and make the fish taste very rancid.

COD is in best condition from November to March. The flesh should rise again when pressed by the finger, and not leave a dent.

EELS should, if possible, be bought alive and killed by dividing the spine just behind the head. Fresh water eels are the best, and silver eels better than dark ones.

FLOUNDERS are rather watery, but very cheap. The best are the plain dark grey ones, without red spots. They should be firm and stiff.

HADDOCKS are very good, nutritious and cheap, and when bought fresh are most delicious.

HERRINGS and MACKEREL should be bought very fresh, not the least faded or wrinkled, or pliable in the tail, but stiff and springy.

SALMON, like all other fish, may be judged by the gills, eyes, scales and general stiffness. When fresh, it has a curd between the flakes. After a day or two, this melts, and the fish becomes richer and more indigestible.

In buying SOLE, choose small ones for frying, and large ones for boiling.

TURBOT are best when of moderate or small size; large ones are more watery. The flesh should be firm, white, plump and creamy. This fish will, if bought fresh, keep two or three days.

PLAICE are very similar to turbot, only not so firm.

WHITING should be cleaned all over. They are the lightest fish to eat when fresh, and very wholesome.

CODLING are often sold for whiting, but they are not nearly as good. They can be distinguished from whiting by their beards.

LOBSTERS and CRABS should be chosen by their weight in proportion to their size. The heavier they are the better.

Fish kept on ice loses its flavour, though it may be quite fresh. It is worth while finding out when the fishmonger receives his fish, and making the purchase then. Be very careful in buying

dried fish. If it be not properly cured, parts soon become bad, and may cause serious disease.

Condiments. To return now to definite adulteration of food.

PEPPER is adulterated with husks, ground olive stones, rice, rape seed, bone dust, etc. Olive oil is sometimes half cotton-seed oil.

MUSTARD is often largely wheat and pea flour, cayenne, plaster of Paris and clay.

PICKLES are coloured with chlorophyll (harmless).

VINEGAR is adulterated with dilute sulphuric acid (vitriol), acetic acid, and caramel. Lemon juice has added to it sulphuric acid, tartaric acid and water.

SWEETS have various substances added. If the colour is soluble it is probably harmless.

Jam. The adulteration of jam is still extensive, and consists largely of carrots, turnips, vegetable marrow refuse, apples, and glucose, which we must always remember is liable to contain arsenic (as seen some years ago in the epidemic poisoning in Manchester from beer so adulterated).

Jams are also adulterated in other ways. Seeds to imitate raspberry seeds are most ingeniously made by a special machine which turns them out in enormous quantities from pine wood. Most of these additions are, however, practically harmless.

HONEY is adulterated with glucose, and GOLDEN SYRUP with starch and glucose.

Beverages. Turning to beverages, we find these are frequently adulterated.

TEA, though no longer faced in green tea with poisonous salts of copper, is still largely adulterated with tea sweepings, old used re-dried leaves, and sometimes clay, lime, or sand, to give weight. Other leaves, such as currant, are sometimes added. Formerly sloe and willow leaves were used.

COFFEE is much adulterated with chicory, sometimes up to 80 per cent., or even more. One-ninth of the coffee and one-sixth of the cocoa examined in London were found to be adulterated—coffee with chicory, roasted wheat, potato flour, acorns, date stones, beans and maize.

CHICORY is the dried and pounded root of a plant, and contains no caffeine. It is injurious in quantities, and has many bad after-effects; but the taste in England is so vitiated that coffee is often preferred with about 30 per cent. of chicory added, while "French Coffee" often has 75 per cent. of chicory, and is sold at about half the price of coffee; 5 per cent. of chicory is not injurious. Under the microscope, coffee has small angular cells, those of chicory being large and oval. In water, chicory sinks and colours it, while coffee floats and does not.

COCOA is adulterated with sugar, starch, brick dust, Venetian red, and peroxide of iron, etc. Sometimes half the fat is removed, which makes it easier of digestion.

Spirits. Alcoholic beverages are particularly open to adulteration.

BRANDY, when first distilled, is colourless, like gin, but darkens with age, and is often coloured with burnt sugar. Other adulterants are chiefly water, cayenne pepper and acetic ether. Much of the brandy sold, as we have pointed out, owes nothing to the grape at all. A recipe for artificial brandy is to add to every 100 pints of proof spirit ½ lb. of argol, some bruised French plums, and a quart of Cognac. The distilled mixture has the acetic ether, tannin and sugar added.

WHISKY is adulterated in the same way as brandy, but is also often prepared from potatoes mashed up with malted barley and roughly distilled and burnt to give it a smoky flavour.

RUM is often fraudulently made from malt or molasses spirit, with a flavouring made of butter, distilled with sulphuric acid and alcohol. This imitates the pineapple.

GIN in England, besides juniper berries, has often oil of turpentine added to it. It is largely adulterated with water, which makes it cloudy; it is cleared with alum and sugar of lead; sugar and cayenne pepper are then added. It is the most adulterated spirit sold.

WINES offer an extensive field to the adulterator. They are generally adulterated by added spirit, artificial colouring, plastering and fancy naming. "Plastering" is adding mineral acids or salts to the wine, and particularly gypsum or Spanish earth. This sulphate of lime clears the wine, makes it look brilliant, and changes the tartaric into sulphuric acid. The object is to make the wine dry.

In cheap wine, aniline dyes, logwood, cochineal, etc., are added for colour. Many imitation ports, sherries and other wines are made in England, sold for a few pence a bottle wholesale, and retailed as foreign wines. British wines are are not made from grape juice at all.

Many wines are also artificially made in Hamburg and elsewhere, ports and sherries from fusel oil, and champagne from rhubarb, apples, etc. German still wines are artificially aerated.

BEER being now legal if not made from malt and hops, cannot be said to be adulterated even when made from quassia, gentian, calumba, and other bitters. Formerly beer was much adulterated; now, except when the materials are themselves adulterated, as in glucose, containing arsenic, the chief adulterants are water, salt and alum. If the SALT amount to over 10 grains per gallon the beer is adulterated.

GOOD AIR

The atmosphere is the vapour or gaseous covering of the globe, on which life depends. It extends everywhere up to a height of 40 miles.

We, on the surface of the earth, are indeed moving about on the bed of a vast air ocean, 40 miles deep, and the pressure of this enormous mass is so great that it is equal to 15 lb. on every square inch of surface. Our bodies, therefore, and everything around us are naturally and instinctively constructed to stand this great pressure, which, being equal on all sides, is not perceived. The force of it is seen at once when it can only press on one side of a body, as, for instance, on the outside of a glass bell from which all the air inside has been removed. The bell is then pressed to the table by the weight of air, so that it cannot be moved. It is probable that

the air ocean is even deeper than 40 miles, for there must be some oxygen at any rate much further than that distance, since meteors burst into combustion at 200 miles from the earth.

What Air Is. We will first of all consider what air is, and then examine the various impurities with which it is adulterated; they are so numerous that it is quite likely that many that have drunk pure water have never yet breathed pure air. The air we commonly meet with has as many ingredients as soup. If we want to breathe pure air such as we are going to describe, we must go to the top of some mountain over 10,000 ft. high, letting no one come with us to contaminate the air. We must face the wind, and then we can inspire pure air. In no part of this country is such air to be found.

Air is a mixture and not a compound like water. In the latter, two gases are chemically compounded and form a liquid. In air two gases are intermixed like sugar and sand, and merely form a mixture of gases without chemical change.

By volume air is one-fifth oxygen and four-fifths nitrogen; or per cent., oxygen 20·9, nitrogen 79·1, and carbonic acid gas (CO_2) ·04. By weight the percentage is oxygen 23, nitrogen 77, and carbonic acid gas ·06. There are also small amounts of other gases and water vapour in pure air.

Constituents of Air. The gases found in air are nitrogen, oxygen and carbonic acid gas (carbon dioxide).

NITROGEN. This is an inert gas used in air simply to dilute the too fiery oxygen. It cannot support combustion or life as a gas, and yet as a chemical element in combination it is an absolute essential of all life. It used to be called "azot"—*i.e.*, without life, and yet there is no organism on earth that can exist without it as an essential food. Nitrogen means the birth giver or the mother of nitre or saltpetre.

It is readily separated from the air by passing air over red hot copper, which absorbs all the oxygen and leaves the nitrogen.

OXYGEN. Oxygen in the air varies very slightly in amount. On the most breezy moor there is 20·98 per cent., or very nearly 21 per cent.; in the closest house there is 20·87 per cent. On a high mountain the oxygen is less than on a moor, because there is no vegetation.

OZONE. Oxygen, again, is of at least three qualities. There is the ordinary oxygen found everywhere; then there is a concentrated form called *ozone*, formed by electricity and the action of the sea water and seaweed round the coasts. This is extremely vitalising, and has a penetrating smell. One part of ozone in 2,500,000 parts of air can be detected by the smell. There is most ozone at night, in the winter, on high ground, round the coast, in the country, after thunderstorms, and with a west wind; there is none normally in towns or rooms. The most that ever occurs is one part to 700,000 of air. It is to this chiefly that the benefit of the sea air is due. Then there is *expired oxygen* that has been breathed and re-breathed, found in crowded resorts. Town air, though it contains the same proportion of oxygen as moor air, is devitalised, because the air is not of the same quality. Air is purified and ozonised by electricity, hence the literal truth of the expression that a thunder-storm "clears the air," and the peculiar fresh feeling of town air after one.

CARBONIC ACID GAS (carbon dioxide). If the amount of carbonic acid gas in air does not exceed 4 parts in every 10,000—that is, ·04 per cent.—the air is not accounted impure. It generally varies in pure air from ·02 to ·04 per cent.

Water Vapour. This is present in all but pure desert air in the dry season, and is necessary for life. The cooler the air the less water vapour will it hold. The greatest amount it can retain in proportion to the temperature is as follows in grains of water to cubic feet of air:

Air	Water	Air	Water
30 cub. ft.	2 gr.	70 cub. ft.	8 gr.
40 cub. ft.	3 gr.	80 cub. ft.	11 gr.
50 cub. ft.	4 gr.	90 cub. ft.	15 gr.
60 cub. ft.	6 gr.	100 cub. ft.	20 gr.

Air saturated with water vapour from 30° to 40° feels very chilly and raw; at 60° saturated air is comfortable; at 100°, as in hothouses, it is close and heavy. The most comfortable amount is from 1 to 1½ per cent. of water (in the form of vapour) in the air, or from 50° to 75° of saturation.

Properties of Air. The chief properties of air are three in number, *weight*, *expansion* and *diffusion*. To the first we have already alluded, and have shown that the pressure of 40 miles of air equals 15 lb. to the square inch on the earth's surface. This pressure is sufficient to support a column of mercury in a ¼ in. tube 30 in. high, forming a barometer, by which the varying pressure of the air is measured. Fifteen pounds to the square inch is one ton to the square foot; and as the surface of the body is 16 sq. ft., the pressure on each person amounts to 16 tons, and yet it is not felt.

The weight varies according to moisture and temperature. Air gets lighter as it gets warmer and wetter, and under these conditions the barometer falls.

If there were no *expansion* of air the separate gases, of which air is composed, would all lie in layers one above another, the lightest at the top This would be the water vapour, then would come the nitrogen, then the oxygen, and at the bottom, next the earth, all the carbonic acid gas, CO_2. This would mean death. Again, if there were no diffusion, by which one gas rapidly changes place with another, there would be no uniformity in the composition of the air, as it is by this law that the carbonic acid gas in the blood rapidly changes place with the oxygen in the lungs, and the carbonic acid gas formed in a town is rapidly removed to the country to be absorbed by plants. On this property again life depends.

So far, then, we have given a brief sketch of air in its pure and normal state. We will now consider the numerous impurities with which all the air we use is really more or less mingled.

Need of Purity. There are two points to notice about air regarded as human food.

One is that, unlike all other food, which can be selected of the greatest purity and best quality from all parts of the world, we are compelled by an inexorable law of nature to use that air that is just in front of our mouths, however foul and poisonous it may be. The other is that where pure air is most wanted—that is, in cities—it is always most difficult to find, because the very men who need it themselves poison it. It is curious to think that seventeen times every minute pure air is a vital necessity, and yet that seventeen times a minute we are pouring poison into it. This is exactly similar to pouring our sewage into our well of drinking water. In air, however, impurity is unavoidable, and to mitigate the evil effects the science of ventilation has sprung up. With this we shall be concerned later. At present we will briefly consider what the impurities are, before seeing how best to remove them.

Impurities are of three classes: gases, organic particles, and inorganic particles.

Gaseous Impurities. These are ammonia, nitrous oxide, excess of CO_2, carbonic oxide, sulphuretted hydrogen, marsh gas and sulphuric acid.

AMMONIA. This arises from all decaying organic matter. The amount in the air is generally about 3 parts in 10,000,000. Rain washes it out of the air together with many other impurities.

NITROUS OXIDE. This is formed from electricity after thunder, and also from decomposing animal matter.

EXCESS OF CO_2. The excess occurs in all indoor air and in much town air. It has been found as follows:

Place	Excess
National School (Leicester)	·2 per cent.
Public Library	·2 per cent.
Assize Court (Manchester)	·19 per cent.
Strand Theatre	·1 per cent.
Bed-room at night	·19 per cent.
Barracks	·05 per cent.
Manchester Station	·04 per cent.
Mine in Cornwall	·78 per cent.
Convict Prison	1·0 per cent.

It occurs in excess in mineral water factories. In London streets it seldom rises above normal—*viz.*, ·04 per cent. When pure, CO_2 is fatal if it amounts to 7·5 per cent., while 1·5 per cent. produces giddiness and fainting. Anything below 1·0 per cent. produces no immediate effect on health. CO_2 is a narcotic and produces deep sleep, hence one often sleeps better (if used to it) in a close unventilated room, through being half poisoned with CO_2.

It is well to remember that CO_2 is heavier than air, and therefore always tends to lie on the floor; hence, the advantage of a bedstead, and the danger of sleeping on the floor in a close room. Its weight can be shown by pouring some into a thin paper box balanced on a scale or on to a light paper overshot wheel, which it will cause to revolve. The reason one hears so much of it as an impurity is because air containing 4 per cent. breathed out 17 times a minute by every human being is laden with organic particles which are more injurious than the CO_2 itself. This poisonous organic vapour clings to walls and clothes, and leaves a room slowly. The CO_2 itself is easy to remove, for it diffuses rapidly; but the organic matter is difficult to remove, for it is not a gas. We may state here that the extreme limits of foul air found in frequented resorts have been as regards deficiency of oxygen 20·6 per cent. in an old courthouse, and, for excess of CO_2, ·7 per cent. in a crowded school-room. This amount is, however, very rare.

CARBONIC OXIDE (CO). This is a far more deadly product, but is fortunately much rarer. It arises generally from unburnt gas, red hot cast-iron stoves, and charcoal stoves. Even ·007 per cent. is quite unpleasant in the air, while ·05 per cent. (the common quantity of CO_2 in the air) is fatal. Even ·01 per cent. has caused death. At an old church at Ambleside, 800 persons were poisoned by it from a heated iron stove. It is formed wherever combustion goes on in close air, and is without smell or taste.

MARSH GAS. This is practically harmless.

SULPHURETTED HYDROGEN. This is a sewer gas.

SULPHUROUS ACID. We find this in the combustion of coal in close places such as underground railways. It is a powerful disinfectant.

Organic Particles. These include pollen from flowers, skin cells, pus cells, bits of insects, germs of all sorts, hair, wood, flax, wool, cotton, paper, silk, starch, manure, vegetable cells, seeds of all sorts, and other organic refuse. The skin cells are in innumerable millions, being cast off the body of each individual daily as dust, and then constantly inhaled. Pollen produces hay fever. Germs are very numerous, and are either harmful or harmless. In London air it is computed that some 14,000 are inhaled by each person every hour, and all are retained in the body, for the expired air contains none. When we consider this fact and think of all the filth with which the air is laden, there is surely a strong argument in favour of breathing through the nose. All inspiration should be so conducted, and then not a single germ enters the lung and no filthy impurities enter the mouth and defile it. No clean person who knows of what dust consists can breathe town air through the mouth on a windy day. The manure and dust in the streets and the disgusting germs connected with it are so common in London air, that during an investigation a short time ago there was not a single specimen of milk from the smaller dairies in London that was not swarming with them.

Continued

FLIES, BEES, AND ANTS

The Life Histories of Insects—continued. Flies and Fleas. Mosquitoes and Gnats. Wood-wasps. Saw-flies. Gall-flies. Bees. Wasps. Ants

continued from page 3516

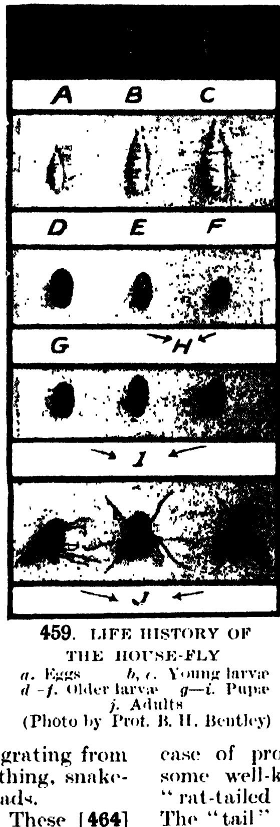
By Professor J. R. AINSWORTH DAVIS

Insects—continued

8. **Flies and Fleas.** This enormous assemblage of insects, most of which are small or even minute, includes many species that have earned an undesirable reputation as blood-suckers and pests. Except in fleas and a few others, such as sheep-ticks, there are only two membranous wings, for the hinder pair of these organs have been reduced to vestiges (balancers), which serve as sensory structures. The mouth parts of the female are very often piercing and sucking organs of great efficiency, the first and second jaws being in the form of slender lancets protected above and below by the upper and under lip respectively [**461**]. But in other types, such as the house-fly (*Musca domestica*), the jaws are modified into a proboscis used for sucking juices, and devoid of powers of perforation [**460**].

The life history exhibits a well-marked metamorphosis, which may be illustrated by reference to the blow-flies (*Calliphora*) or the house-fly [**459**]. The elongated whitish eggs ("fly-blows") are laid in animal substances, such as meat, and hatch out into limbless maggots of extreme voracity. After growing to a certain size, these become quiescent ovoid pupæ enclosed in firm investments, from which the adult flies ultimately make their escape.

Hessian flies are minute forms, of which the larvæ greatly damage grain crops, while the fungus flies are also very small, and lay their eggs in fungi, as these constitute the food of the young. The little maggots which riddle mushrooms are of this nature. The larvæ of some of these flies (*Sciara*) are known in the Northern Hemisphere as "army worms," because millions of them may sometimes be seen migrating from place to place, aggregated into writhing, snake-like masses by means of sticky threads.



459. LIFE HISTORY OF THE HOUSE-FLY
a. Eggs *b, c.* Young larvæ *d–f.* Older larvæ *g–i.* Pupæ *j.* Adults
(Photo by Prof. B. H. Bentley)

Mosquitoes and Gnats. These [**464**] are particularly notable for the blood-sucking propensities of the female. The larvæ are little worm-like creatures which may be seen wriggling about in stagnant water, and possess a breathing tube at the tip of the tail, that can be pushed above the surface to procure air. The pupa floats at the surface, with two breathing tubes projecting from its head. If alarmed, it is able to dive. After a time the pupal skin opens and the perfect insect makes its way out.

Agents of Disease. Some tropical mosquitoes disseminate the germs of such diseases as malarial fever and sleeping sickness. Wholesale destruction of the early stages, by pouring petroleum on the surface of the stagnant water in which they live, has been employed with great success at Havana as a preventive measure against yellow fever and malaria.

Midges are very minute gnats, of which the aquatic larvæ are known as blood-worms. Crane-flies are familiar to us in the persons of daddy longlegs (*Tipula*), well adapted for climbing among grass. The larvæ (leather-jackets) gnaw the roots of grasses, and become pupæ in the ground [see AGRICULTURE, page 1667]. Sand-flies are small gnats of unusually bloodthirsty disposition; their larvæ are aquatic.

Voracious Flies. In the flies so far described the antennæ are long, but in the others now to be mentioned they are short. Of these the breeze-flies or gad-flies possess powerful piercing mouth-parts, with which they torment both stock and human beings. A well-known species is the long brown clegg (*Hæmatopota pluvialis*), often met with in woods. In some tropical kinds the jaws are of enormous length [**462**].

Robber-flies are voracious and insatiable forms which prey upon other insects, even wasps, dragon-flies, and tiger-beetles being among their victims.

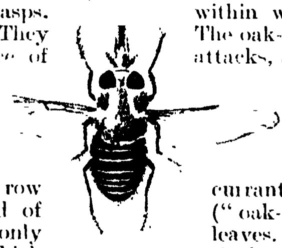
Hover-flies are swift and elegant insects which have already been mentioned in connection with flowers. Some of them closely resemble bees in appearance, and this has been described as a case of protective mimicry. The larvæ of some well-known species (*Eristalis*) are called "rat-tailed maggots," and live in liquid filth. The "tail" is in reality a breathing tube. Other larvæ (*Volucella*) inhabit the nests of bees and wasps, and probably act as scavengers. House-flies, blow-flies, and many others make up yet another family. The dreaded tsetse-fly (*Glossina morsitans*), so fatal to horses in parts of South Africa, belongs here [see Plate facing page 3361]. Germs of the fly-sickness (*Nagana*) are introduced into the blood of the victims. The

460. HEAD OF HOUSE-FLY
a. Antennæ *b.* Eye
c. Proboscis

bot-flies have been described and illustrated on pages 2626 and 2627 in the course on Agriculture.

Fleas. Fleas [463] are wingless members of the order, and their agility fully compensates for the loss of the power of flight. There are many species infesting different mammals and birds. The females of the tiny sand-fleas, or chiggers (*Sarcopsylla penetrans*) of tropical America deposit their eggs in the feet of human beings (or other animals), and unless the painful swellings thus brought about are carefully treated they are apt to fester dangerously. Probably the slang expression, "You be jiggered!" is an invocation to this unpleasant insect.

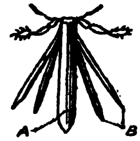
9. **Membrane-winged Insects.** These constitute a vastly numerous group, including, among many others, ants, bees and wasps, the most intelligent of their kind. They are readily recognised by the presence of four transparent wings traversed by a comparatively small number of veins, the hinder ones being much smaller than the others, to which they are in many instances attached during flight by means of a row of minute hooks. The posterior end of the body in the female is commonly provided with a piercing apparatus, which may either serve for boring holes, in which eggs are laid, in which case it is called an "ovipositor," or may have been modified into a poisoned sting, useful for offence and defence. The conspicuous black and yellow, or black and red bands, of wasps and bees are "warning colours," indicating their stinging powers.



462. NEPAL LONG-BEAKED GAD-FLY

The larvæ either resemble caterpillars, or are pale, helpless maggots, devoid of limbs, for the welfare of which more or less elaborate provisions are made by the mother insect. Later on, a quiescent pupa stage is reached, from which the winged adult ultimately emerges. The highest members of the order live in communities comprising several castes, as in termites. These include males, perfect females (queens), and one or more kinds of imperfect female workers (soldiers).

Wood-wasps. These insects somewhat resemble wasps in appearance, except that they do not possess the characteristic "waist" and sting. The giant wood-wasp [see Plate facing page 3361] is a typical species, in which the female has a powerful boring apparatus, with two strong blades that serve as augers for perforating the trunks of sickly or felled pine-trees. The eggs laid in the holes thus made hatch out into wood-eating larvæ. The life-history is somewhat prolonged, and the perfect insects have been known to escape from wooden furniture after the lapse of several years.

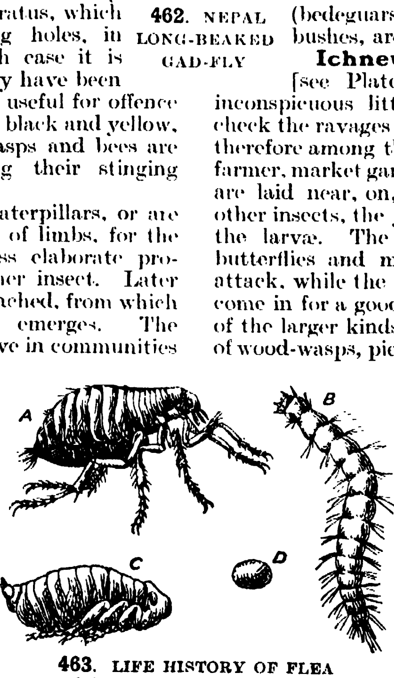


461. JAWS OF BLOODSUCKING FLY
(Spread out)
a. Upper lip
b. Lancets

Saw-flies. In these small insects [465] the female possesses an ovipositor, consisting of two elegant curved saw-edged blades, sliding on supports. The larvæ somewhat resemble little caterpillars, and are notorious insect-pests. Rose-trees and currant-bushes are commonly attacked by some of our native species, while others devastate the turnip crop.

Gall-flies. These are minute black insects, the females of which are provided with slender ovipositors, used in piercing soft vegetable tissues, for egg-laying purposes. A kind of irritation is set up, resulting in the growth of an abnormal swelling known as a "gall," within which the larva lives and feeds. The oak-tree is particularly liable to such attacks, and is victimised by a large number of species. The most familiar case is afforded by the spherical brown bodies known as "oak-apples," while other common oak-galls look like currants, or circular brown scales ("oak-spangles") on the backs of the leaves. The curious tufted red swellings (bedeguars) often seen on wild rose-bushes, are of similar nature.

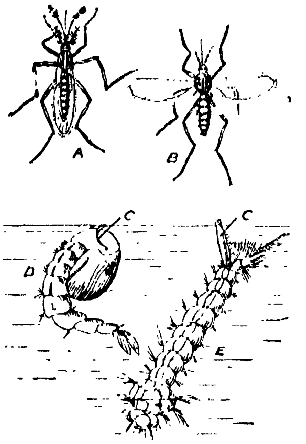
Ichneumon Flies. These flies [see Plate] make up a host of mostly inconspicuous little creatures, which go far to check the ravages of vegetarian insects, and are therefore among the most valuable friends of the farmer, market gardener, and forester. Their eggs are laid near, on, or in the immature stages of other insects, the juices of which are absorbed by the larvæ. The caterpillars and even eggs of butterflies and moths are favourite objects of attack, while the destructive plant lice (*aphides*) come in for a good deal of attention [467]. Some of the larger kinds check the ravages of the larvæ of wood-wasps, piercing infested timber with their powerful ovipositors [468]. In this way they are able to deposit their eggs in the galleries of the wood-wasp larvæ, to which their own larvæ attach themselves on hatching out. One of our native gall-flies actually makes its way under water for the purpose of attacking caddis worms.



463. LIFE HISTORY OF FLEA
a. Adult *b.* Larva *c.* Pupa *d.* Egg

Bees. These familiar insects construct cells of various materials in which they lay their eggs, and devote most of their time to feeding and

caring for the helpless larvæ. Some are solitary forms, but between these and the complex communities of humble bees and honey bees there are various intermediate stages. Their dependence upon the pollen and nectar of flowers has been elsewhere considered, but it will be well to remember that their structure has been profoundly modified in relation to their peculiar diet.

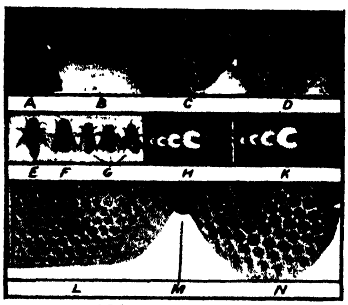


464. LIFE HISTORY OF GNAT
a. Male *b.* Female *c.* Breathing tube *d.* Pupa *e.* Larva

Carpenter Bees. These are large and handsome insects which build their nests in dry wood. After biting out an entrance, the female constructs three or four parallel tunnels, each of which is divided into a number of cells separated by partitions constructed of sawdust cemented together with saliva. Each cell contains an egg, together with a store of food.

Carder Bees. These bees make their cells in ready-made hollows, sometimes using empty snail shells for the purpose. The material employed consists of down from the stems and leaves of various plants. This is skilfully woven into the cell walls, cement being added to prevent the stored honey leaking out.

Leaf-cutting Bees. These nest in various hollows, walling-in their cells with pieces of leaves glued together. One species native to this country employs the scarlet petals of the poppy in this sort of upholstery work.

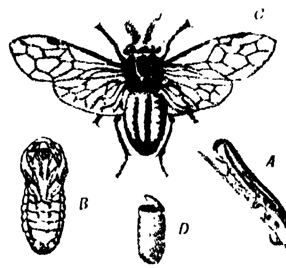


466. HONEY BEE
a. Worker brood (covered) *b.* Drone brood (covered) Drone brood (uncovered) *d.* Diseased comb *e.* Queen *f.* Drone *g.* Workers *h.* Larvæ and pupæ of workers *k.* Larvæ and pupæ of drones *l.* Worker cells *m.* Commencing comb *n.* Drone cells (Photograph by Prof. B. H. Bentley)

Mason Bees. Mason bees have been studied with painstaking care in the South of France, and the following are a few of the details observed. A flat stone having been selected as a foundation, the first cell is made of earth worked into a kind of mortar with saliva. This is then stored with honey and pollen mixed together into a sort of sweet paste; an egg is next laid, and the cell roofed in with mortar. Other cells are now added, to the number of eight or nine, and the whole is covered with mortar and small stones. The completed nest is convex in shape and about half the size of an average orange.

467. ICHNEUMON FLY ATTACKING PLANT-LOUSE

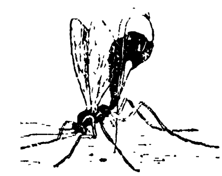
Cuckoo Bees. Like their namesakes among the birds, cuckoo bees have acquired the vicious habit of taking advantage of the industry of some of their allies for the benefit of their progeny. One such form (*Stelis minuta*) victimises another bee (*Osmia leucomelana*), which constructs its cells in blackberry stems. The intruder lays an egg in the midst of the provisions stored in each such cell, and as the destitute alien is the first to hatch out, it grows more rapidly than the lawful owner. Ultimately the two larvæ meet, that of the cuckoo bee killing and devouring its opponent.



465. PINE SAW-FLY
a. Larva *b.* Pupa *c.* Adult *d.* Cocoon

Gregarious Bees. Helping to explain the origin of communal life among bees are certain cases—*e.g.*, *Halictus*—where a number of females undertake a certain amount of work for the common good, excavating a branching tunnel in the ground, with an entrance and vestibule used by all. But each individual constructs, stores, and finally lays her eggs in cells as an entirely independent task. A comparison may almost be made with a series of flats opening upon a common staircase, and with one front door between them. And just as in such a congeries of human dwellings an individual employed by all may be responsible for front door and staircase, so among these particular bees a sentinel is set at the entrance to the burrow. In what manner this functionary is appointed remains to be shown.

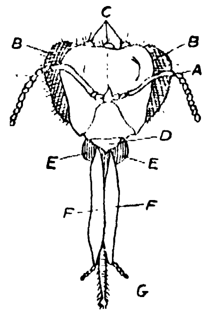
Humble-bees. [See Plate facing page 3361.] These common bees are large, somewhat clumsy-looking insects which live in communities including workers or imperfect females as well as ordinary members of the two sexes. The nests are constructed in holes in the ground or other sheltered places, and the establishment of a community is due in the first instance to the labours of a foundress queen in early summer. She makes a number of waxen cells, stores them with honey and pollen, and afterwards feeds the larvæ



468. ICHNEUMON FLY BORING WOOD

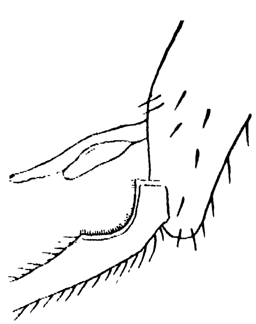
when they have devoured these provisions. From the first (and several other) batches of larvæ workers are chiefly produced, which undertake the constructive and nursing work, until at last the queen has nothing to do but lay eggs. Males and other queens are reared from some of the eggs laid in late summer and early autumn.

The brood-cells differ in size according to the destiny of their occupants, the smallest being designed for workers, and the largest for queens. Pollen and honey are stored in special receptacles known as pollen-tubs and honey-tubs. Living in the nest of a humble-bee (*Bombus*), and on good terms with the members of the community, are to be found individuals belonging to a related genus (*Psithyrus*). These construct their cells in association with those of their hosts, and steal the honey and pollen which these have stored up for their own benefit.



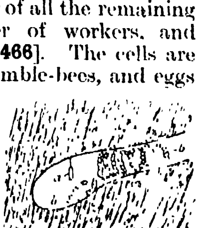
469. HEAD OF WORKER WITH PROBOSCIS EXTENDED (FRONT VIEW)
a. Feelers *b.* Compound eyes *c.* Simple eyes *d.* Upper lip *e.* First jaws *f.* Second jaws *g.* Tongue

One species of humble-bee, at least (*Bombus ruderatus*), is known to appoint a "trumpeter," which wakes up the community at three or four o'clock in the morning.

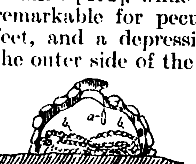


471. FEELER-COMB

The Honey-bees. The honey-bees (*Apis*) are so well known that it will be unnecessary to say much about their habits, especially as details will be found in the course on Bee-Keeping. A community consists of a single queen, the mother of all the remaining individuals, a large number of workers, and numerous drones, or males [466]. The cells are of different sizes, as with humble-bees, and eggs that would otherwise give rise to workers may be made to produce queens by feeding the larvæ which hatch from them with more stimulating diet, and assigning them large "royal cells."



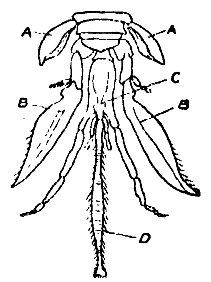
Odynerus renifo...



Eumenes

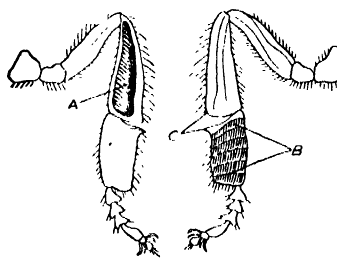
473. NESTS OF SOLITARY WASPS (IN SECTION)
a. Suspended eggs of wasp *b.* Stored caterpillars

Structure of Honey-bees. Many of the points in the structure of the honey-bee fit it for the performance of its complex activities. Upon the head there are two large compound eyes, used for near vision, and three small simple eyes by which objects at a distance can be perceived [469]. There is a well-developed sense of colour, and flowers which specially lay themselves out to attract bees are mostly of blue or purple hue. Bees have also a keen sense of smell, which not only attracts them to fragrant flowers, but also helps them to detect the presence of nectar.



470. JAWS OF WORKER SPREAD OUT
a. First jaws *b.* Second jaws *c.* United third jaws *d.* Tongue

The mouth-parts of the bee are highly specialised [470]. The powerful first jaws (mandibles) are used in the construction of the comb, and for a great variety of other purposes, while the second and third jaws are drawn out into a long suctorial and licking apparatus. The basal part of this constitutes a tube through which nectar or other sweet fluids can be sucked up, while its terminal portion is a sort of tongue (*ligula*) that can be inserted into the recesses of flowers. This [470] is worked up and down so as to bring nectar within the tubular part of the apparatus. The end of the tongue is expanded into a sort of lappet for licking, and the sharp blades of the second jaws can be used for piercing certain flowers, such as orchids, which contain sweet sap. When not in action, the suctorial parts of the mouth are folded up on the under side of the head, enabling the first jaws to work freely.



Outer side Inner side
472. THIRD LEG OF WORKER
a. Pollen basket *b.* Pollen brush *c.* Wax pincers

There are marked differences between the three pairs of legs of a worker-bee. The first are provided with combs, by which the delicate antennæ are cleaned [471], while the third [472] are chiefly remarkable for peculiar pollen-brushes on the feet, and a depression or "pollen basket" on the outer side of the shin. The hairy feet brush pollen into the baskets, and when of dry nature, a little honey is ejected from the mouth on to the grains, so as to stick them together. Another peculiarity of the third legs is the nature of the joint between shin and foot, which constitutes a sort of pincers useful in manipulating wax. The wax used in constructing combs is secreted in the form of little plates by glands opening on the under-side of the abdomen.

Solitary Wasps. Wasps, like bees, are either *solitary* or *social*, and it is only in the latter that workers exist.

Solitary wasps construct small nests of clay and little stones, or else make burrows. They possess the curious habit of storing up immature—for example, caterpillars—or mature insects, or even spiders, for the benefit of their larvæ when these hatch out [**473**]. The kind of victim depends upon the species of the wasp concerned, but in any case it is killed or paralysed by stinging.

Social Wasps. Social wasps somewhat resemble social bees in their habits, but their building material instead of being wax is a kind of paper made of chewed wood mixed up with saliva. In some instances, the nest is suspended from a bush or tree, as in the example figured [**474** and **475**], and is provided with a kind of overhanging roof by which rain is drained off. In our commonest native species (*Vespa vulgaris*), an underground site is chosen, and a series of combs constructed from above downwards, the whole being enclosed in several layers of wasp-paper. Adjacent combs are held together by little pillars [**476**].

474. HANGING NEST OF HERMIT WASP
a. Roof *b.* Entrance

The young are at first fed upon fruit-juice, nectar, and other vegetable matter, for which a more stimulating diet of chewed insects is afterwards substituted.

The hornet (*Vespa crabro*) [see Plate facing page 3361] is a social wasp which commonly nests in hollow trees.

Ants. These familiar and intelligent diminutive creatures are perhaps the most interesting of all insects, owing to the extraordinary way in which they have become adapted to a great variety of modes of life. All are social, and a community typically consists of males, females, workers (of one or more kinds), and, it may be, soldiers. The two first are generally provided with wings, though those of the female are soon shed, but exceptions to this occur, and some species may have both winged and wingless individuals of one sex or the other. The first pair of jaws (mandibles) are well or even excessively developed, and possess unusually free powers of movement in accordance with the varied functions they have to perform. In many cases, the females (including the workers) are provided with a sting.

475. HANGING NEST OF HERMIT WASP
Cut open from below to show comb
(Photographs by Prof. B. H. Bentley)

Ants hatch out as helpless limbless larvæ, which have to be fed and carefully attended, either by the fertile females or the workers, as the case may be. Feeding is rather a curious affair, for the nurse possesses a sort of pouch (crop) connected with her gullet, and this is used as a store from which nutriment can be squeezed up into the mouth. Adults can feed one another in the same way, as also the little beetles and other insects which are often found as guests in their communities.

The *wandering* ants that are to be found in the tropics are of highly carnivorous habit, and move about in large armies, devouring everything of animal nature that comes in their way. The fact that they are blind, or practically so, does not seem to interfere with their devastations. Some of these forms (*Eciton*) are common in the hotter parts of South America, while others, the "driver" ants (*Anomma*), are well known in Africa, where criminals, it is said, are sometimes tied up in their path, to perish miserably, if speedily.

Robber Ants. Ants which steal the supplies of other species belonging to their own family are not infrequent. The brown meadow ant (*Formica fusca*), that occupies subterranean dwellings, is subjected to the unwelcome attentions of a smaller species (*Solenopsis fugax*) living in narrow galleries [**484**] communicating with the broader ones of its host, which is unable to follow the depredators into their fastnesses.

If the walls of our houses were riddled with galleries inhabited by a pigmy race of marauders the situation would be a similar one, supposing our intelligence were not sufficient to tackle effectively the problem of protection.

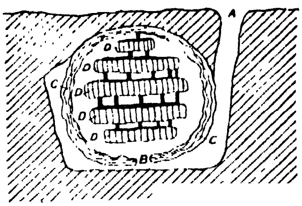
Slavers and Slaves. Some of the ants have anticipated human malpractices in the way of slaving by pressing weaker species of their kind into unmerited captivity. In one familiar instance the relatively large oppressor (*Polyergus rufescens*) is of reddish colour and well endowed in the matter of jaws [**480**], while the enslaved species (*Formica fusca*) is small and dark. Regular slave raids are made from time to time, when, after a stubborn resistance, the pupæ and older larvæ of the weaker form are carried away to lead a life of bondage, to which, indeed, they take very kindly. This kind of social economy has indeed become an absolute necessity to the slavers, which have quite lost the power of feeding their own young, while some such species cannot feed themselves.

A most extraordinary state of things occurs in the case of a small kind of ant (*Anergates*) which possesses no workers of its own, but lives

within the communities of another species (*Tetramorium cæspitosum*) entirely made up of workers. What has become of the males and females of the host under such circumstances is not definitely known.

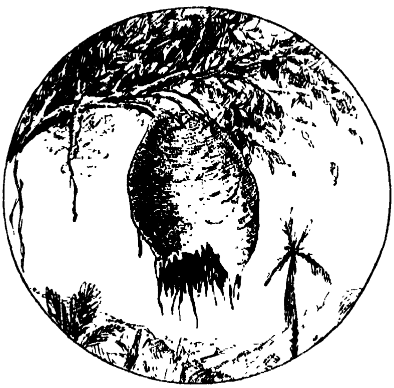
Cow-keeping Ants. Some ants, such as the little black species (*Lasius niger*) common in gardens, use as part of their food a sweet fluid that exudes from plant lice (*aphides*), and keep these insects as we keep kine [477]. The captives are fed, sheltered, and jealously guarded. Fenced enclosures are constructed for them on plants in the vicinity of the nest, with which they are connected by covered roads. During winter, the fragile eggs of the plant lice are taken underground and sedulously cared for.

477. ANT MILKING A PLANT-LOUSE



476. SECTION OF COMMON WASP'S NEST
. Hole in ground b. Entran Covering f wasp-paper d. Combs

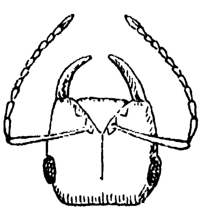
Honey-pot Ants. There are certain ants (*Myrmecocystus*) native to the United States and Mexico, and others (*Plagiolepis*) found in South Africa, which have adopted a remarkable method of storing surplus honey that may have been collected. Certain individuals remain in the nest and play the part of living "honey-pots," swallowing the sweet fluid that is administered to them until their distended crops dilate th abdomen to an enormous size [485]. It is supposed that th members of the community are able to draw from this store when necessary.



479. HANGING NEST OF A SOUTH AMERICAN ANT

Harvesters. In Europe, North Africa and North America, a number of ants are known that construct extensive underground dwellings, in which they store seeds of various kinds.

Some of the American species (*Pogonomyrmex*) may be even said to winnow their grain, for they carefully strip off the husks and deposit these on rubbish-heaps outside the nest.



480. HEAD OF SLAVER ANT

Maltsters and Mushroom Growers. Some of the seed-storing ants almost deserve the name of maltsters on account of the way they deal with their harvest. The human method of making malt is to allow the barley grains to germinate to a certain extent until the contained starch is converted into malt-sugar, when the process is arrested by scalding. In similar fashion ants permit germination to go on to a certain point, and then kill the seedlings by biting away the little shoots and roots. In this way a supply of the sweet food they love is secured. Among the most interesting of ants are leaf-cutting forms (*Atta*) native to tropical America. They are associated in huge communities occupying complex underground dwellings, the sites of which are marked by mounds that may measure as much as 40 yards round. The chief food consists of a kind of fungus (*Rozites gongylophora*), cultivated on bits of leaf, and treated in such a way that little white swellings are produced [482]. It is these that the ants desire.

478. GUEST-BEETLE OF ANTS BEING FED AND CLEANED BY TWO WORKERS

The chief duty of one set of workers is to collect the pieces of leaf required. To facilitate their operations, roads, largely underground, are constructed, which lead to suitable trees, and may be as much as 20 yards long, or more. Curved pieces of leaf are bitten out and carried back to the nest, where they are handed over to another set of workers, by them to be reduced to smaller fragments and made into mushroom beds.

482
a. FUNGUS GARDEN OF ANTS
b. TOADSTOOLS PRODUCED NATURALLY BY FUNGUS

Something has been already said about plants which are in possession of body-guards of ants, for which both food and shelter are provided by the rest of the community. Such plants are often more or less modified as an adaptation to this curious kind of mutual benefit association. A well-known instance is afforded by the bull's horn acacia of Brazil, the large hollow thorns of this being inhabited by the guardian ants for which a special kind of food is provided

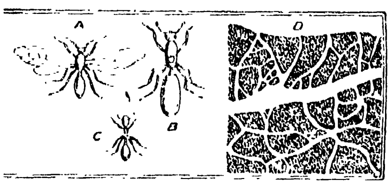
481. HANGING GARDEN OF A SOUTH AMERICAN ANT

in the form of nutritious "food bodies"—namely, little swellings on the tips of the leaves. The acacia benefits by this arrangement, for the ants keep off leaf-cutting insects. Certain small birds have also learned to build in the branches of this acacia, the ant-guards of which prevent the visits of monkeys and other enemies.

Some South American trees (*Cecropia*) also maintain ant-guards (*Azteca*) that live within their hollow stems, in each joint of which there is a little round pit, serving as a ready-made front door to the dwelling provided. At the base of each leaf-stalk there is a swelling covered with brown hairs, between which grow little "food bodies" for the benefit of the ants.

In some of the East Indian ant plants there is a basal swelling [**483**], traversed by a labyrinth of passages in which the attendant insects find a commodious dwelling. These passages are formed naturally and not excavated by the ants themselves. Some such plants are flower-bearing species, while others are ferns.

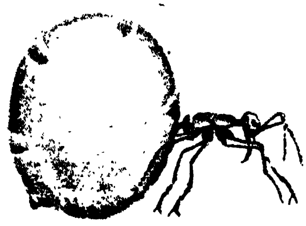
Homes of Ants. It will already have been gathered that ants live in dwellings of the most varied kind, many being underground. In a large number of species ant-hills are constructed of various loose materials, our common native wood-ant (*Formica rufa*) being a good example of this. An Asiatic ant (*Oecophylla*) constructs a summer-house of leaves in a curious fashion. The larva possesses silk-glands from which a sticky fluid exudes, hardening quickly on exposure to the air. Advantage of this is taken by the workers, for they hold larvæ in their jaws, and employ them as living gum-bottles, while the leaf edges to be cemented are held in position by other workers.



484. ROBBER ANT

a. Male *b.* Female *c.* Worker *d.* Part of nest (in section); the robbers live in the narrow passages

Hanging Nests and Gardens. Some of the South American ants construct hanging nests in trees [**479**], by which protection against floods is secured. Other ants in the same part of the world make curious homes which well deserve the name of "hanging gardens," for they are mainly constructed of living plants, some of which have never been found in any other situation [**481**]. The plants are cultivated and tended by the ants with which they are associated. The soldiers of certain ants (*Colobopsis*) which tunnel out homes in the wood of trees play the part of living front-doors. Every entrance to the nest is guarded by one of these hall-porters, its huge head not only exactly filling the aperture, but closely resembling the adjacent bark in appearance. If this curious door be touched by a bit of stick or a feather, it remains shut, but is immediately opened when stroked by the antennæ of a worker.



485. HONEY-POT ANT

Ant Guests and Associates. Not only may ants of two or more kinds be associated together in the same dwelling, but a nest may also be tenanted by peculiar species of beetles (and other insects), spiders, mites, or other creatures. Many of these, especially the beetles, are fed [**478**] and cared for by the ants, some of them for the sake of a substance which exudes from their bodies, others, perhaps, to serve as pets.

483. ANT-PLANT, NATIVE TO JAVA (In section)

The beetle-grubs are looked after as well as the adults, at least in the case of certain blind species. It is probable, too, that some of these guests perform the duties of scavengers.

Harboured Thieves. On the other hand, certain ant-beetles not only steal food from the ants, but also devour their young. There can be no doubt that these curious associations are very ancient ones, for many species of beetle are found nowhere else. A kind of bristle-tail that lives in ants' nests is a thief pure and simple. It has been seen to steal the drops of honey being passed from the mouth of one worker to another, afterwards retreating at full speed for fear of unpleasant consequences.

The common red ant (*Myrmica rubra*) shelters and feeds a curious kind of blind mite, which lives on the bodies of its hosts. By stroking its entertainers with its legs it makes known its need of nutriment, and such requests are never refused. Not impossibly some return may be made for these good offices, but, if so, their nature is so far entirely unknown.

One of the Indian ants (*Sima rufo-nigra*) lives on the bark of trees with a species of wasp (*Rhinopsis ruficornis*) and a kind of spider (*Salticus*), both of which closely resemble it in appearance. The three associates appear to be good friends, while wasp and ant sometimes engage in a friendly wrestle.

Means of Communication. The complex life of an ants' nest is a striking instance of order among apparent disorder. Each of the innumerable individuals discharges its special tasks without hesitation, unless unusual circumstances prove a hindrance. It would seem, therefore, that there must be some means by which one ant can convey information to others. When two meet they frequently stroke one another with their feelers, and this perhaps serves the purpose of language.

Continued

Group 24 PHYSICS 26 Continued from page 3620	THE MYSTERY OF COLOUR

Continued from page 3620

THE MYSTERY OF COLOUR

What Colour is. Why the Sky is Blue. The Dust and the Sunset. The Spectrum. The Mind and Colour. Vision. Colour-blindness

By Dr. C. W. SALEEBY

WE know what colour is essentially—that it is precisely comparable to pitch in sound, and that one pure colour differs from another, if the complications introduced by our seeing apparatus be ignored, neither more nor less than red differs from the infra-red heat rays, or F from G.

How Colour is Made. Colour is a matter of wave length and of frequency of vibration. The onward speed of all forms of light is the same. Indeed, we have seen that this speed is one and the same for ethereal vibrations in general, and not merely for the octave we call light ; but the factor of time enters in an entirely different way into our study of light. For though red and violet light both pass onwards at the same speed, the vibrations constituting the first occur at the rate of four hundred billions (400 millions of millions) per second, while those constituting the latter are about twice as frequent. There is a due proportion between wave length and frequency, so that as the wave length becomes shorter the frequency of the vibrations increases. It is when we think in terms of frequency per second that we recognise, most completely, the precise parallelism between colour and pitch. We turn now to a further study of colour as dependent upon the relation between ethereal waves and material matter ; and also as dependent upon the peculiarities of our retinæ. The analogy with sound will help us no longer, but we shall be helped, in some measure, by our previous study of *Radiant Heat*.

Why Red is Red. It was a saying of St. Augustine's that light is the queen of colours. We may read a modern meaning into this if we consider the reason why a piece of red glass appears red. So long as no light is allowed to fall upon or pass through the glass it has no colour, but is as black as everything else about it. Its redness, then, depends upon the manner in which it acts on the light which it receives. White light is the queen of colours because it contains all the colours, and a piece of red glass is red because it transmits the red elements in white light, but is opaque to all the others. Why it should be transparent to red, but opaque to everything else, is a further question which we can make no attempt whatever to answer. If the reader will consider it for a moment, he will see how difficult it is, and how entirely it depends upon an adequate knowledge of the nature of matter itself.

Meanwhile, we must content ourselves with the empirical unexplained fact that certain kinds of matter have certain relations to ethereal waves of certain lengths. The explanation of the redness of a red object is thus only partial, but it is unquestionably true as far as it goes ; and it applies alike to bodies which are red by transmitted light and those which are red by reflected light. A piece of red paper is red because it absorbs all the constituents of the white light which falls upon it, except the red which it reflects.

These assertions can easily be proved by experiment upon the spectrum. We find that a piece of red glass reduces the spectrum of white light to its red elements, cutting off the others, while a piece of red paper appears red in the red part of the spectrum, but black everywhere else—because it is compelled to absorb all light except red.

What Makes the Sky Blue? It is this principle of selection which explains many of the most glorious colours of Nature. If we ignore, as we may, the stars, nebulæ and comets, and the moon and planets that gain their light from the sun, then all the colours of the sky and sea and land are to be referred to the white light of the sun. Why, then, should the sky be blue? This subject was very carefully studied by Professor Tyndall, who showed, now about forty years ago, that the explanation is to be found in the presence of excessively fine particles that float in the atmosphere and, because they are so fine, scatter light of very short wave lengths, while allowing light of longer wave lengths to pass through. Doubtless there is a certain amount of scattering of all the rays, but the short blue waves are much more scattered than the others, and thus endow the sky with its blue colour. It is a somewhat prosaic explanation of the spendid colour which we associate with the firmament, that it is due merely to minute particles of " dust " in our atmosphere—the total thickness of which, of course, as compared with celestial distances, is infinitesimal.

How the Dust Paints the Sunset. Reference has already been made to the peculiar shape presented by the sun when it is very near the horizon. It is now our business to explain the magnificent colouring which we see at sunrise and at sunset. The light leaving the sun is white at all times. What, then, is the reason of the apparent redness of the sun when it is near the horizon, and of the colouring that is produced around it? The answer is that when the sun is near the horizon, and the rays are piercing the atmosphere very obliquely in order to reach our eyes, its light is affected much more by the particles in our atmosphere than when the sun is overhead—since it encounters more on its way. As must be, the blue rays are especially scattered, and it is by the red rays especially that we see the sun

at such times. Every Londoner is familiar with the fact that the presence of an exceptional amount of dust in the atmosphere on a foggy day similarly affects the appearance of the sun. Indeed, it may be said that the sun is never white in London, but is yellow even at noonday. It has recently been noted by M. Rodin, the great French sculptor, that Londoners are fortunate in the magnificent effects of colour which their sky often yields them. This is some compensation, but a very inadequate one, for the filthy and health-destroying fashion in which we burn our coal. Lastly, it may be noted that whenever a large amount of volcanic dust is thrown into the atmosphere exceptionally brilliant and magnificent sunsets are observed. This was the case after the eruption of Krakatoa, the eruption at Martinique, and the recent eruption of Vesuvius.

The Spectrum. We now turn to a subject which is on the borderland between physics and psychology, and which can never be properly understood unless we are careful constantly to distinguish between the phenomena which have a physical or objective explanation and those which have a psychological or subjective explanation. Let us begin, first of all, with the physical.

It is the physical fact that the light which we call white can be decomposed into a spectrum. It is also, as might be expected, the fact that the various colours thus decomposed can be re-composed or combined so as to form white light again. This can be done by throwing the spectrum on to a series of mirrors, so placed that they all throw the light falling upon them on the same spot on a dark screen. The spot reflecting to the eye simultaneously this mixture of rays will appear white. Various other means will produce the same result, provided that, as in this case, not only are all the necessary colours present, but they are present in the proportions in which they exist in white light. Now, if we manipulate our apparatus so as to prevent the green constituent of the light from falling upon the screen, we shall find that the illuminated part of the screen is no longer white, but red; or, if the yellow constituent of the light be interfered with, the spot will appear blue. The relation between such colours as blue and yellow which, taken together, form white light—so far as our eyes are concerned—is expressed by the word *complementary*. This means that if white light be taken as full light, blue fills up yellow to that fulness (Latin *pleo*, I fill).

The Absorption of Light. We must distinguish very carefully, however, between the behaviour of lights of complementary colours, such as blue and yellow, and pigments of corresponding colours. If blue and yellow lights are mixed together, the result is white light, but, as everyone knows, if blue and yellow paint are mixed together, the result is not white paint, but green paint. For the moment this may appear paradoxical, but it will seem so no longer if we think more carefully of the difference between the two cases. In the case of the paints, their colour depends solely, as we have already seen, upon the colour of the light which they are not able to absorb. The light which cannot be absorbed by blue paint, but is reflected by it, is green, blue, and violet. Similarly, yellow paint reflects merely red, yellow, and green. This is as much as to say that when the two paints are mixed, the only colour which they cannot absorb between them is green, and hence that is the colour of the mixture.

A simple device will show the difference between mixing blue and yellow paints and blue and yellow lights. The latter can easily be done by any of many methods, and the result is the production of a white or grey light.

Colour Impressions on the Eye. Newton began the study of this subject by a very simple and effective method, "the use of rotating discs which quickly superpose on the same area of retina different impressions of colour." Newton gave precise directions for the size of the seven sectors bearing the seven colours, from red to violet, which were to be painted on a disc of cardboard, so that, when the disc was rapidly rotated, it appeared to be of a uniform grey, approaching more and more to whiteness in proportion to the strength of the light by which it was illuminated. Clerk-Maxwell had the excellent idea of applying Newton's colour disc so as to make a colour-top. This is simply a flat top of a size suitable for holding a number of coloured discs, made with a hole at the centre so that they can slip over the handle of the top. Each disc has a slit in it, so that various pairs of discs may be fitted into one another, simultaneously exposing various pairs of colours in any proportions that may be desired. Then the desired result is obtained as soon as the top is rapidly spun. As the top rotates more slowly, the retina becomes unable to retain the successive impressions long enough for their combination, and thus successive flashes of colour are seen.

Deceiving the Eye. There are various ways in which the retina may be deceived so that the sensations of complementary colours are subjectively produced. Thus, after looking at a red spot very fixedly for a few seconds, one sees a green spot of similar size when one turns the eye to a white surface. The explanation of this extremely interesting though familiar fact is that the retina has refused to respond to the red constituent of the white light which is sent to it from a white surface, and so interprets the white light as green. We may possibly discern some further explanation of this when we turn to colour vision. Complementary colour sensations may also be produced subjectively by what are called *Gorham's discs*, and by various other methods. In all such cases the explanation is beyond the reach of pure physics, and must be sought in the facts of colour vision.

In another respect, also, the retina may be deceived. It interprets as simply yellow light two entirely distinct forms of external stimulus. The yellow light which, as we have seen, is given out by sodium, is a pure mono-chromatic yellow, all consisting of vibrations of one and the same length. But various other colours may be so

artfully mixed that when their combination is submitted to the eye it interprets them also as yellow. In other words, the eye has no power whatever of distinguishing between a *pure colour* and a *mixed colour*.

The Brain and Colour Sensations. The explanation of these subjective colour sensations, as also the discussion of the circumstances in which they are aroused, is of the utmost interest in relation to painting and the kindred arts. There is some evidence to show that these complementary sensations are not due to anything that happens in the retina itself, but to the behaviour of the vision centre at the back of the brain. Thus, for instance, if one eye be closed and a brilliantly-coloured object be looked at with the open eye, the complementary colour sensation may be seen in the closed eye, which suggests that, in some mysterious way, the first colour appears in one part of the vision centre in the brain, and its complementary appears in the remainder. Then, again, if a colour and its complementary are seen at one and the same time, each appears richer and finer than it otherwise would—a fact which is apparently to be explained by the theory that each colour produces the other—or, rather, a sensation of the other—in that part of the vision centre which it is not itself affecting. This it is which explains the agreeable effect of contrast, provided that it be a harmonious and not a discordant contrast. What we call a harmony of colours probably depends on the process which we have just described—each component of the "chord" of colours producing its complement in the part of the vision centre which it is not itself stimulating.

Can Colour be Standardised? There are certain elements or constants or physiological characters which are associated with every colour, and we must try to analyse these and to use, in this analysis, a series of definite terms. In point of fact, common language is never looser than when discussing colour. The language of art criticism is equally defective in this respect, words like *tone* and *shade* being used with extraordinary elasticity. It may also be noted—though we have no present remedy to offer for it—that the notation or terminology of colours in general is extremely defective. Such a term as *red*, of course, includes colours of very different wave lengths, and our attempts to define a particular kind of red are as often misleading as not. Very many students have attempted to devise some kind of notation for practical use, but none of these have hitherto been successful. Thus, when a lady wants to match a particular colour, she cannot write to the shop and say that she wants a red of 358 billions (358,000,000 millions) per second, but has to go and take a piece of the stuff with her. If we remember the analogy between colour and pitch, we shall see that there is no inherent reason why colours should not be standardised just as musical instruments are standardised to English or French pitch.

The Elements of Colour. The first character of any colour is its *hue* or *tone*. This depends absolutely and without qualification upon the wave length and frequency, and needs no further discussion.

In the second place, there is the character sometimes described as *purity* and sometimes as *saturation*. The word *tint* is sometimes employed to describe this character, but most unfortunately so. The saturation or purity of a colour depends upon the amount of white which is contained in the colour. A perfectly pure or saturated colour, such as any of the pure colours of the spectrum, contains no white whatever; whereas the more the admixture of white with the colour, the less pure it is. Plainly there may be an infinite number of degrees of saturation from, for instance, an absolutely pure red, on the one hand, to a colour, on the other hand, which one would describe as a white having the faintest possible tinge of red.

The third character of any given colour is indicated by such words as *brightness*, *luminosity*, and *shade*. The best word for its description, however, is *intensity*. The intensity of a colour, in any given case, may be determined by two factors. In the case of a given eye at a given time, it depends upon only one factor—namely, the extent or amplitude of the ethereal vibrations. It may range, of course, from the most brilliant and luminous to the darkest and most sombre shades.

A Red Rag to a Bull. Our use of the word *amplitude* will at once have shown the reader that intensity or brightness in the case of colour is absolutely parallel in every respect to loudness in the case of sound. But it must also be remembered—and this is true of sound as well—that there is a subjective or physiological factor which determines brightness or intensity, for one and the same colour may appear intolerably bright to one eye, while it is almost sombre to another. As an instance, we may take the colour red, often known as the *dynamogenous* colour—that is, the colour which *produces force*. We must believe that a red which has no marked effect upon ourselves has a far more intense influence upon the retina of a bull, which it may arouse to behaviour justifying the name of dynamogenous. In certain morbid states of the brain, and in certain criminals and in lunatics, a red colour may act similarly.

Perhaps the oldest and simplest theory of colour vision was that the visual cells of the retina—the rods and cones—are thrown into vibration in unison with the ethereal vibrations that excite them. This theory has to be dismissed if only because such rapidity of movement of ponderable matter, as distinguished from ether, is quite inconceivable. The light energy cannot merely be transferred to the visual cells; it must be transformed. We have already noted certain consequences of this transformation—electrical consequences, changes in the pigment cells, and so on.

The Theory of Colour Vision. The most widely accepted theory of colour vision, or *colour perception*, as it is somewhat undesirably called, goes by the names of Young and Helmholtz. The theory appropriately comes from these two great men, since they were both

originally doctors, who, having received a physiological training, then turned their attention to physics. It was propounded by Young in 1807, being thus scarcely less than a century old, and was revised and elaborated by Helmholtz in 1852. This theory begins by taking into account the known fact that we are not capable of receiving simple colour sensations corresponding to every colour in the spectrum, but that if three primary colours are allowed us, their combinations will yield us impressions equivalent to all colours. The assumption, then, is that our vision is trichromic—that is to say, that it is based upon three primary colour sensations. The Young-Helmholtz theory assumes, then, that the retina must contain three kinds of photo-chemical substances—that is, substances which can be chemically influenced by light. These three substances are respectively sensitive to the three "primary" colours—*red, green, and blue* or *violet.* (Thus "primary" here has only a physiological meaning—not a physical.)

How Colour Strikes the Mind. These three substances are supposed to be connected with three corresponding sets of nerve fibres, and these fibres convey to the brain impulses in various proportions according to the wave length of the light with which the retina is stimulated. The following is the statement of Helmholtz as to what actually happens under stimulation by various colours, according to the trichromic theory of vision:

"1. Red excites strongly the fibres sensitive to red, and feebly the other two—sensation, Red.

"2. Yellow excites moderately the fibres sensitive to red and green, feebly the violet—sensation, Yellow.

"3. Green excites strongly the green, feebly the other two—sensation, Green.

"4. Blue excites moderately the fibres sensitive to green and violet, and feebly the red—sensation, Blue.

"5. Violet excites strongly the fibres sensitive to violet, and feebly the other two—sensation, Violet.

"6. When the excitation is nearly equal for the three kinds of fibres, then the sensation is White."

The arguments for and against this theory might be discussed at any length. Its most celebrated modification is known as *Hering's theory,* and is about a quarter of a century old. It is really a modification of Young's theory. Both of these theories, and also all other theories that have been put forward, find their most important illustrations and tests in the extremely interesting and important fact known as *colour-blindness.*

Colour-blindness. It is not our business here to discuss colour-blindness as a disease, nor its extraordinary transmission from grandfather to grandson by means of an intervening daughter and mother who does not herself suffer. We have to discuss the disease in relation to its physics, and as regards its practical consequences. It was first named by Sir David Brewster. The most famous case on record is that of the illustrious chemist John Dalton, who had "red-blindness," and studied his own condition in the year 1794, by the aid of the spectrum. Hence the disease is often known as *Daltonism.*

We may briefly note some forms of colour-blindness. In complete colour-blindness, "the spectrum appears in shades of grey throughout, being lightest in the position of the yellow-green, and darkest at each end. A coloured picture appears like a photograph or an engraving. According to the Young-Helmholtz theory, such cases are explicable on the assumption that all the three photo-chemical substances are alike," as is indeed believed to be normally the case in the outlying portions of the retina, which can readily be proved to be incapable of perceiving colour. In other cases the whole spectrum may appear in shades of one colour, suggesting that only one photo-chemical substance is present.

Partial Colour-blindness. But the common condition met is partial colour-blindness, which may be either green-blindness, blue-blindness, or red-blindness. Of these the most important are the first and last. In green-blindness the spectrum is not shortened, but contains no green. Furthermore, it is *di-chromic* —that is, consists of only two colours, with or without a neutral area of grey. The two colours composing the spectrum are a reddish-yellow and blue. Such patients confuse bright green with dark red, and cannot see at all a dark green letter on a black ground.

In *red-blindness,* or Daltonism proper, the spectrum is shortened, since the red end is absent, and it consists merely of two colours—yellow and blue. Such patients cannot distinguish between dark green and light red, nor can they see a dark red letter on a black ground.

Here we can merely allude to cases of incomplete colour-blindness, the range of which may be indefinitely extended. It is unquestionable that the eye of the painter sees very differently from the eye of the average person who, relatively to the painter, certainly suffers from incomplete colour-blindness. When a lady complained to Turner that she could not see all those colours in the sunset, he replied, "Ah! madam, don't you wish you could?"

The Consequences of Colour-blindness. Colour-blindness is mainly a disease of the male sex. In all nations, about 3½ per cent. of the men are colour-blind. Now, red, green, and white are universally adopted as signals to indicate danger and safety, and these are just the colours which the colour-blind men mistake. On the other hand, other colours cannot be substituted for them, since they do not transmit nearly so much of the light behind them. Thus, it is necessary to exclude colour-blind men from such work as that of signalmen; and this is done by causing them to match coloured worsteds In order to study the colour sense most perfectly, one should employ the pure spectral colours, and Lord Rayleigh, among others, has constructed instruments for this purpose. The worsted test universally goes by the name of *Holmgren,* of Upsala, who was the first to employ it in a systematic way.

Continued

CYCLOPÆDIA OF SHOPKEEPING

JEWELLERS. The Shop and its Fitting. Selection of Stock and Stockkeeping. Prices and Profits. The Repairing Department

LICENSED VICTUALLERS. From Potman to Proprietor. "Tied" and "Free" Houses. Finance. Profits. Legal Requirements

MANICURISTS. The Practice of Manicuring. Operators and their Salaries. Equipment of Premises

MASSAGE SPECIALISTS. Facial Massage Treatment. Assistants and Charges. The Massage Parlour

MILLINERS. Practical Training. Capital. Show-room Requirements. Business Hints. Advertising

JEWELLERS

The business of a jeweller stands upon a different plane to most other shopkeeping departments. It possesses many technicalities, and demands the possession of a good practical knowledge of its rudiments and a theoretical knowledge of its many details. For instance, the successful jeweller must be familiar with the different qualities of gold peculiar to Britain, America, and the Continent, with rolled gold, and gold cased, also with the various precious stones, their degress of colour, the various forms of cutting them, etc. We shall assume that our reader has the above knowledge, and a sum of £500, an amount by no means excessive. A smaller capital will curtail the ability to make an efficient display, except by getting into the hands of the wholesalers, which the beginner should avoid. If one were certain of doing a fair return from the commencement, it would be otherwise; but jewellery being one of the first trades to suffer in times of depression, reserve capital is essential.

Location. The first thing we have to consider is the site. The degree of ambition has an influence in determining that factor. A start may be made in city, town, or country, and the choice made from these three determine the rent and taxes to be paid, also the nature of the fittings, and the class and quality of stock required.

The city and town life are more strenuous than the country, the risks greater, but the success is also greater if attained. Nothing is gained without a certain amount of risk. But the timid, those who would be worried mentally over the thought of risks, are better to decide upon the easier and less expensive district. In any case, one must try and get a position or shop as close as possible to the centre or shopkeeping thoroughfares where the business is done, for few of the public go out of their way to purchase jewellery. The beginner in the city should not pay more than about £100 per annum rent, with the capital we mention, for rates and taxes will at the least be equal to one third additional. Six months' rent and taxes ought to be held in reserve, which, on the above basis, is approximately £65.

Fittings. One must study the district and see the class of goods that are more or less in demand, thereby forming an idea as to the necessary elaborations in fitting up the shop. Try and work out a design of your own, even if it should be rough in its nature; strive to get into it a distinctive feature; too much of the present mode of working and constructing is stereotyped. It is distinctiveness, be it ever so slightly varied from the common run, that attracts the eye of the public. In your plan, lay stress upon the design of your window. Plan it so that you are able to get the maximum of articles into it without crowding, otherwise you lose the distinctive nature and characteristics of your goods. The interior of your shop, also, must be nicely fitted and arranged. Eschew the old style of ebony colour and gold lines, which have served their day. Although effective in some instances, for the average shop the style is too dark and heavy, and shows marks too plainly. Find out if there is in the district a jewellers' shop fitter, one who understands the making of airtight cases. Lay your idea before him regarding the window especially, and out of his experience he will be able to assist you. First of all, consider the sum you ought to allot for that purpose. Here we would add that somewhere about £100, at the outside, should be earmarked. Let the fittings be as good as possible. Better modify somewhat the interior fittings than the window arrangement.

Stock. While the shop is being fitted up, you should be looking up the stock necessary. Look round your district, and find out the nature of goods in demand, more for the style of design and quality than anything else. We shall presume here that our beginner has had some experience among the manufacturers and wholesale houses, and therefore possesses the knowledge of the markets for his respective articles. If he be known personally, he will most likely be able to purchase on usual terms from the start; if not, he will require to give some references from people of standing, and probably to pay cash up to half the value of the goods selected. Of course, he can do without references if he proves that he is in the trade, tells where he is starting, and pays cash for the lot. Once the wholesalers and makers get your confidence and find that you are upright, know the business, and are determined to make a success of your venture, you will then get their usual terms. The terms of the various houses vary a little, but the majority work on a 5 per cent. discount for 30 days, 2½ per cent. for 60 days, 90 days net. A few give only 2½ per

cent. discount for 30 days, and after that net. One thing to be careful about is overbuying before you are sure of your district. Select articles that you believe to be in demand. In other words, simply form a nucleus upon which you can work. It is easier to get new stock in than to get rid of old and unsaleable goods. A nice selection, arranged so as to make your shop appear full, is all that you require to begin with. Let that nucleus be composed principally of the genuine material—gold and silver, etc.; then you have at least making-up price in the market value of the material, whereas rolled gold and imitation jewellery, once soiled, is difficult to renew or make fresh. Stock to the value of about £200 should be ample to begin with. That should include principally the everyday articles, such as rings, brooches, charms, necklets, lockets, pendants, with an assortment of gold, silver, and metal watches; muff chains are not in great demand at present. Of gents' gold alberts, stock a few only, as they are cut so much that they are practically not worth handling, but they cannot be entirely neglected.

Where to Buy. To those in the trade it is pretty well known that Hatton Garden and Charterhouse Street are the districts in London where the wholesale jewellers congregate. In Clerkenwell Road and the surrounding district there are several very good houses, where you can get everything and anything of good quality and at reasonable prices. For the country in general outside of London, Birmingham is the home of the jewellery manufacturing trade, and there all qualities of jewellery may be obtained—good, bad, and indifferent; even London cannot do without Birmingham. The names of many good houses will be found in the retailers' monthly, the "Watchmaker, Jeweller, and Silversmith," published at 150, Holborn, London, E.C. However, the individual firm need not trouble the beginner, for he will not be long open before he is found out by the army of travellers looking out for fresh business. Here we warn our novice not to believe all that is told him by the knights of the road. The retailer must set his mind firmly against being influenced to take what he is not certain will sell. One cannot avoid a little dead stock, but to keep it as little as possible constitutes the art of buying.

Stockkeeping. Having attained the necessary stock, the next duty is to take a record of it in what is called a *stock book*, noting the description of each article, the number attached to it, and its cost. See that the stock is kept clean, as well as the window and shop. Nothing deteriorates in appearance as the result of finger marks more than gold and silver surfaces when finished, and nothing looks more shabby. The salt that is in the perspiration has a chemical action, and if not wiped off at once it is almost impossible to get it off afterwards, as the surface is eaten into. Therefore, the few minutes spent with the chamois leather is both time and money saved.

We advise that very little rolled gold or gold-cased articles be stocked. There are, of course, certain districts where the bulk of the trade is done in that class of goods, but here we are dealing with jewellers as jewellers, not as fancy goods shops. Later on, the jeweller can judge if there is much demand for such goods in his district, and, if so, it is quite easy to procure stock. Better to work on the above principle than load oneself at the beginning with doubtful articles. In reference to profits in general, it is not wise to run under $33\frac{1}{3}$ per cent., and get 50 per cent. if possible. One must bear in mind the nature of the trade. Jewellery is not a necessity of life where you are sure of a certain turnover day by day, and, as we have stated, it is the first trade that is subject to suffer from general or local depression. Meanwhile, the expenses are running on and have to be met, for the landlord and the tax-gatherer do not take the ups and downs of your business into consideration.

Repairing. There is one source of revenue to be made which is a great help in a small business—namely, the repairing department. Nearly all jewellers take in watch and jewellery repairs. If you are a watchmaker you can fill up your spare time at that branch, and if you have not enough work to employ a practical jeweller, you can always get such work done at a trade shop; in every town there are some, but one can find out only by experience the best and most reasonable. Avoid cutting a man down too much, for you will only get value accordingly. Although the finished article may look all right, in a very short time it will reveal its nature, and then you will have trouble with your customer, or lose him altogether. Most people are open to reason, and a little explanation before taking in hand a piece of work to be repaired or cleaned properly at a fair price, is understood. If customers attempt to beat you down, as some will, it is preferable to refuse to do the work rather than take it in and do it unsatisfactorily. Again, however, with a regular customer one has to come and go a little. There are many articles that will take up a man's time so long that the public eye cannot see where the value comes in; and it is then difficult to convince as to the reasonableness of the charge. But one's judgment and tact must be brought into play, and, as a rule, matters will right themselves.

We have not touched on silver plate because the sum on which we have been considering cannot well include this department. That can come later on if the business warrants it, and the subject is treated in another article in this course. But a few fancy ornaments, etc., with an assortment of clocks should be added, those being necessary to every household.

General Policy. It will be observed that we have absorbed £365 out of the £500, leaving £135 in hand. It is not to be expected that the beginner will pay his way from the day of opening. Jewellery is a business about which the public as a whole know little, and it takes time to gain confidence. But confidence once inspired, every effort should be made to retain it. At the opening there are incidental expenses

that are not thought of at the moment, but which cannot be avoided, therefore the odd £35 can be looked upon as pretty well absorbed. So, with the £100 in hand, with care in management, and by sticking closely to business till it is established, one should be able to develop and command the wholesale market pretty well through being able to meet the accounts as they become due, thereby also saving the discount. It is these small items that help one in this world of competition.

One item to be remembered is the gold and silver licence issued by the Government in two forms. The retailer may sell articles up to two ounces of gold and 30 ounces of silver on the licence at £2 6s. per annum, and for all above that weight the sum is £5 15s. It is advisable to become a member of the National Association of Goldsmiths, which assists and protects retailers who are members.

LICENSED VICTUALLERS

The trade of the licensed victualler is not usually regarded as a branch of shopkeeping. Although there is no fundamental reason for this, the view is to some extent justified by the great differences which exist between the conditions of selling excisable liquors and those of all other branches of retailing. No other trade is so encompassed and hedged about with laws, so subject to legal regulation in all its details, or so great an object of the attentions of social reformers and zealots. From the time of Edward VI., when the first licensing Act was passed (1532), at least fifty principal Acts affecting "the trade" have become law, of which four-fifths have come into being in the last 170 years.

Working-up. There are very few proprietors of licensed houses who started life in "the trade," chiefly for the reason that the conditions of employment in beer and spirit selling have little or no attraction for smart businesslike young men, and do not foster those habits of industry and energy which go far to make the successful proprietor. Further, barmen, and even managers, have no great opportunity or incentive to save money. Another reason is that it is not a trade which requires the experience of a lifetime, for it is so bound and fettered by laws and by the system of "tieing" houses that there is little room for development by enterprise. Nevertheless, men have worked their way up. The lowest grade of employee in the trade is the potman. Formerly his office and pride was the keeping and polishing of the pewter pots. Now, however, he has degenerated into a general handy-man, his duties ranging from sweeping out the bar to "chucking" out its obstreperous occupants. The wages vary from 10s. to 16s. per week living in, or 20s. to 27s. out. On Saturday nights or other busy times he may be called upon to help behind the bar, and thus get a footing therein and obtain an under barman's place. From under barman at 12s. to 17s. per week to head barman at 18s. to 26s. is a matter of personal progress.

A Managership. The ambitious man will combine the duties of cellarman with those of bar supervision and serving. He may not get extra pay for doing so, but he will accumulate valuable experience which will enable him to take advantage of a managership opportunity later on. The cellarman is responsible for fining the ale, for the condition of the beers, keeping the spirit vats and the earthenware supply casks for the bar stocked, and for keeping the bar supplied with the bottled goods as well as for the absolute cleanliness of the cellar and its utensils. By watching advertisements in the trade newspaper—the "Morning Advertiser"—or the trade journals, or by the help of convenient friends, he will achieve his next step—to manage a house either as working manager under the proprietor or as manager in sole charge. The character of the post naturally depends upon his experience. He should be married. With his wife to take charge of the housekeeping side (providing food for the bar and the staff and managing the household affairs) and to serve in the bar on occasion, he may obtain from £2 to £4 a week with board and lodging and will draw about 10s. a week extra per head for the board of the staff. If unmarried the manager is generally expected to provide a female assistant to undertake these duties.

"Tied" and "Free" Houses. Next must be considered the man with a limited capital which he desires to invest in a public house. He may be our manager who has saved a few hundred pounds. Public houses are divided into two definite classes—houses which are "free" and houses which are "tied," the latter far outnumbering the former. In 1893 only 12·8 per cent. of London houses were entirely free, and since then the number has been greatly reduced by brewers' purchases. In the provinces they are still fewer. Prices almost fabulous have been paid for free houses in the past. Their value lies in the fact that they are not burdened with loans, whereas the man who runs the "tied" house is either indebted to a brewer for part of his capital (lent on mortgage) or may be only the brewer's tenant. In both cases he must buy his beer from this one brewer at higher rates or smaller discounts than the "free" man, and if he has also received an advance from a distiller he is also bound in the purchase of spirits. Free houses are now so few in number and their prices so high that they do not come within the range of this article. They are objects of ambition for the man of considerable capital.

Capital. A man with a small capital may either start as a brewer's tenant or as landlord of a small tied house. The novice may be attracted by advertisements offering tenancies which can be entered upon with a very small inclusive capital, say, £150 to £200. But it is necessary to lay stress on the fact that it is practically useless to lay out money in taking over a house doing the very small trade which only can be expected for such a sum. A living trade is hardly possible where the takings of the house are less than £100 per month. For capitals of from £300 to £500 a man may reckon upon being able to obtain modest tenancies of houses turning over, according to locality (town, suburban,

or country) and class of trade, from £100 to £250 per month. These capitals will be made up as follows: Deposit with brewers, £75 to £125; loose effects, £100 to £150; stock, £50 to £100; cash in hand, £40 to £75; legal and brokers', etc., charges and proportion of licence duty, compensation fund payment, rent, rates and taxes, £35 to £50. This may sometimes be reduced a little by arranging with the brewers and distillers to take over part of the stock, which is bought back as trade requires. The lower capitals will apply to the provinces where houses are more completely tied than in London and other large centres.

Similar houses on lease from brewers instead of on a tenancy agreement will need capitals of from £1,500 upwards. They possess the advantage that they can be sold by the landlord, at a profit perhaps, making speculation possible; and also that, in the event of extinction, the lessee gets a considerably larger proportion of the compensation than the tenant. But the responsibilities and amount of possible loss are much greater, of course.

A beerhouse, licensed only for the sale of beer, would probably need a capital of only about £150 for a trade of £100 per month. The licence duty and working expenses are somewhat less than in the case of the fully-licensed house, but the trade is on a lower grade and the profits and possibilities smaller.

Choosing a House. A good training for a landlord of small capital, new to his responsibilities, is afforded by a tenancy—under brewers of standing, of course—in a semi-working-class neighbourhood, where most of the houses are classed as "small property," and where there are plenty of people walking about. The trade is more easily worked than any other town trade. Beer is the article mostly sold, for the English working man drinks little or no spirits. The day trade in the jug department will also be good. This class of house has an advantage over a larger establishment, in that it depends mainly upon regular customers, who, if well served, will not be drawn by the larger house with many lights, which depends more and more upon passing custom as its size increases. Brewers' rents for these houses are very variable, and are usually more than the ordinary rental value of the property. They may be anything from £50 to £100.

The man with little capital may also do well with the tenancy of a small country inn. The prices obtained will be lower, and the profits smaller than in town, but the rent will probably be nominal (£20 to £40), and there will be the advantages of grounds, fruit gardens, poultry keeping, and stabling, all of which will contribute to the income. Grounds and outbuildings will enable him to cater for motorists and cyclists; fruit, vegetables, and poultry will supply visitors' meals. In a small country town the tenant may let the stabling, if he does not wish to work it himself (which entails the expense of an extra man), at from £10 to £15 per annum, to a local jobmaster, who will work it in association with him.

New houses are very rare in the trade. The capital required, and the risks of losing it, are considerable. Justices will grant new licences only for entirely new districts, and even then are generally very reluctant to do so. The licence is granted before building, if the justices approve the plans and other details, but the licence has to be confirmed when the house is ready to be opened, which means that the battle has to be fought over again with the possibility of confirmation being refused. If confirmed, it is granted for a period of seven years, and at the end of this period has to be renewed as a new licence, with no right to compensation if extinguished. To open a new house of the type above indicated would require a capital of from £3,000 to £5,000, according to the location—country or town.

The Broker. In the actual choice, the services of a trade broker are indispensable, partly because the market is entirely in the brokers' hands, and also because the many legal formalities incident to entry to the trade are likely to entrap the novice. If reasonable care be exercised in the choice of a man, those who offer El Dorados for trifling sums being shunned, there will be little cause to regret the small percentage on the amount of the transaction absorbed by the broker. Having obtained from the broker particulars of houses likely to suit his desires and capital, whether in town or country, the prospective landlord should personally visit the house offered, and decide the choice for himself. He must investigate the duration of the lease, the total loan burdens on the house, and the reputation which the house has with the local authorities, inquiry being made of the clerk to the licensing magistrates, in order to ascertain whether the Register of Licences (which is open to inspection) contains any record of transgression by a former holder of the licence. These matters are most important, and there is much room for the novice to buy dear experience. They should all, therefore, be rigorously investigated by his broker, and only when he is satisfied should further steps be taken.

Profits. In taking over any business, that which ultimately decides the question of purchase is the quality and quantity of trade done, and in this trade it is paramount. A tenant who is tied only for his beer, should make not less than from 33 per cent. to 37 or 38 per cent. total gross profit on his takings, and from 30 to 35 per cent. if he be tied for spirits as well as beer. These figures do not pretend to finality, but indicate what the prospective purchaser may reasonably require for the class of trade outlined. If, for any reason, the figures supplied by the vendor are suspected, the receipts for the amounts paid to the brewer and distiller will give definite information as to the quantity and quality of the business done by the house, and the purchaser may reasonably require their production.

Loans and the Purchase. Although starting in business in the licensed trade on loans raised by mortgage to brewers and

distillers is a feature of the trade, it is highly undesirable, as elsewhere, to saddle oneself with the burden of loans from brewers or from private sources. The man whose house is heavily mortgaged, and who is accordingly stringently "tied," is fettered in all ways, and proper development becomes difficult if not impossible. Certainly, the man who takes the modest tenancy here referred to should not need to borrow.

A house may be bought "all at" or by valuation. The first term means an inclusive price for the lease (if any), the fixtures, and all utensils appertaining to the business, but excluding the stock, which must be valued. The inventory of the trade accessories and fixtures should be shown to the representative of the brewer to whom the house belongs, to ensure that none of the articles catalogued belong to him, which, of course, the vendor cannot sell. Buying a house by valuation simply means that the price is based upon inventories made by the representatives of the seller and the buyer of everything, including the stock. When the tenant or purchaser formally takes over the business, the ceremony called the "change" takes place, when the valuations are checked and the purchase money is handed over—always in cash, never by cheque.

The Legal Transfer. The transfer of a licence is attended with many legal complexities. Before the "change" is accomplished the incomer's broker secures for him a "protection order," to enable him to sell excisable liquors until the next meeting of the Special Licensing Sessions, of which from four to eight are held during the year. Full details of the formalities will be supplied by the broker, or will be found in such a book as Mr. W. Makins' excellent "Licensed Victuallers' Handbook," wherein will also be found much legal and practical information relating to "the trade."

The Licence and its Renewal. In reality, the licensed victualler has two licences—the Justices and the Excise. But as the issue of the latter is entirely dependent on the granting of the former, it is usual to regard them together as "the licence."

Publicans' or victuallers' annual licences in the United Kingdom for spirits, beer and wine to be consumed on or off the premises are of three kinds: (1) the full licence, for the sale of excisable liquors during all the hours not specified by the Act of 1874; (2) the six-day, or early-closing licence, in accepting which the licensee agrees to remain closed during Sunday, or to close an hour or more earlier than the time stipulated by law; and (3) a licence which combines the features of which are alternative in 2. The duty on the second and third licences is respectively one-seventh and two-sevenths less than that on the first. The choice of the licence will be determined by local conditions.

The duty is based on the rateable value of the premises, and varies, for the full licence, from £4 10s. for premises rated under £10 to £60 for premises at or above £700. For houses whose rateable values are between £50 and £100 the duty is £25. The assessment is based on the rent payable.

It has been held that holders of existing licences have a *primâ facie* right to renewal, and the power of refusal, on other than certain well defined grounds connected with the fitness of the holder or his premises, is vested in Quarter Sessions, on reference from the justices and on payment of compensation from the trade fund instituted by the 1904 Act. The licensed victualler has, therefore, now more prospect of continuity in his business than formerly; but if he be only a brewer's tenant his share of compensation is rarely, if ever, sufficient to cover his losses on the extinction of the licence.

Preserving the Licence. Keeping the licence when it is obtained is not an easy matter. It may be directly forfeited upon conviction for seven particular offences, including felony, keeping a disorderly house, selling spirits without a spirit licence, and making intercommunication between licensed and unlicensed premises. Further, convictions for serving drunken persons or children under 14 in open vessels, allowing the premises to be used for betting, gambling, or allowing customers to be on the premises, or billiards to be played, after prohibited hours, are entered upon the Register of Licences, and regard is had to them by the justices when a renewal or transfer is wanted.

The staff must keep very wide awake to prevent betting slips being passed, though it is very difficult to detect this. If the loser of a bet pays it by paying for drinks it is an offence under the Gaming Act. The laws affecting the public-house and the preservation of its licence are many, and the licensee must be thoroughly acquainted with them. The trade year-books, or Mr. Makins' "Handbook," give full information on all these matters.

Fittings. Under the 1902 Act all alterations or additions of a structural nature have to be approved by the justices, and there is no appeal from their decision. Plans should be submitted before such alterations are carried out, or the justices may order the premises to be reinstated in their former condition. Structural alterations include shifting a counter or a screen, but not the renewal or addition of beer engines. The result of the restrictions is that alterations are expensive, and rarely carried out. When they are, it is a matter for local architects and builders, for there are practically no firms of public-house fitters. In the case of the tenant such expense, where necessary, falls upon the brewer. A semicircular bar is the most convenient shape where possible, for it is more easily supervised, and can be worked with a smaller staff than the bar of square or three-quarter circle form.

For the bar-floor mosaic is best, but is expensive. A good inlaid linoleum is also hygienic. Sawdust absorbs moisture, but a non-absorbent floor is cleaner.

All fittings and utensils will be included in the transfer, and it will not be necessary, therefore, to deal with them here in detail; when

renewal is necessary the catalogues of good firms of bar-fitters will show what can be done. It may be noted that liberal lighting with incandescent gas-lamps is a feature of the publican's show. Electric light is more costly.

Country Trade. The country publican will trade as an innkeeper, which entails the compulsory reception of guests. The trade is included in the full victualler's licence. In the case of the small house there will be little profit derived unless visitors are more or less regular. Supplying meals to cyclists, motorists, and other road travellers may be made very profitable if it can be done in quantity. Small trade means much waste. On ordinary catering a gross profit of at least 50 per cent. should be made. As much as 75 per cent. gross profit may be made on teas if they be purveyed in large numbers. The profit on luncheons is more precarious, but country produce will help. Outbuildings for storage are almost essential to the man who caters for cyclists and motorists. In them petrol and calcium carbide can be stored and supplied at profitable rates. Licences, costing 5s., must be obtained from the local authorities in each case. Cyclists and motorists are always appreciative of good service and catering, and a permanent connection may be built up. If the landlord can persuade a cyclists' club to make his house its country headquarters it will pay him. The same remark applies in greater force to Masonic and other lodges.

The Cellar. It is probably not too much to say that profits are made or lost in the cellar, and the importance of method can hardly be overestimated. In a small business it will usually pay the publican to be his own cellarer so far as its management and arrangement are concerned. In any case he should "break down" spirits himself, and possibly also "fine" the ales. "Breaking down" is a mathematical operation which should be conducted strictly with the aid of the hydrometer and sliding rule, and according to published tables for spirit strength reduction. "Fining" is the clarification of ales by the addition of isinglass or other "finings."

Drinks must be appetising. Wine and beer must be clear and aerated water sparkling. Aerated waters are, happily, becoming more and more important in their relation to the prosperity of the licensed victualler. To ensure the proper condition of liquors it is necessary to adjust carefully the storage conditions for each article. Beer in casks and bottles should be kept at a temperature of about 55° F., port and similar wines at 60° F., and light wines and spirits at about 40° F. These temperatures must be carefully maintained, which can be done conveniently by means of a set of thermometers (such as Hicks's), indicating the temperatures for the respective articles.

The cellar must be well ventilated, for bad air deteriorates the stock. To keep it sweet it should be washed out once or twice a week, and the walls whitewashed annually. Care should be exercised to avoid spilling beer, for spilt beer is apt to breed vermin.

Burtons and bitters should be stocked a fortnight before sale, so that they may become bright by depositing the sediment.

Racks must be provided for empty bottles. Much waste occurs if they are not preserved from breakage, for the price of the bottles represents the total profit on many bottled articles.

The gantries, or stillions, on which the casks rest, must be solid and substantial, so that the beer or spirit may not be shaken up. To preserve the liquor from the effects of the vibration which is often observable in towns, they frequently rest on sand.

The pipes connecting the cask with the bar engine must be kept scrupulously clean, or the best liquors kept under the best conditions will be spoilt. The pipes are preferably of fine tin in 6-in. sections, connected by special joints of pure rubber, and it must be one of the chief duties of the cellarman to look after them. They should be washed out frequently with hot soda solution, followed by plentiful flushing with fresh water.

Sidelines and Amusements. Though dealt in by all publicans, and therefore not strictly sidelines, tobacco, minerals, cider, and wines may be briefly referred to here. The licence for tobacco and snuff dealing is always taken out with the liquor licence, and costs 5s. 3d. per annum. The profit will not be more than 25 to 30 per cent. gross, and considerably less in the case of those provincial houses which are tied to the brewer for tobacco, and the trade will not be large. It is quite an easy trade, however. On minerals, the gross profits should not be less than from 25 to 30 per cent. for bottle sales, and 35 to 40 per cent. for sales in glasses. The trade is considerable, and is easily cultivated. Cider and wines will be very little sold in the small house, and even in the larger houses the trade is not large. It is chiefly absorbed by wine and spirit merchants.

Amusements in licensed houses are so frequently the source of trouble with the police that in many cases publicans have ceased to supply them. Automatic pianos distinctly tend to cause disorder, and may be removed as public nuisances on the complaint of householders. To keep a public billiard table, a special licence is necessary, full-licence holders, however, being exempt. It has to be applied for at the annual Licensing Sessions, and the conditions which apply to liquor licences also apply to it, except that it expires on April 8th in each year. The holder must display a notice to that effect similar to the liquor licence signboard. A good room with two tables may bring in as much as £5 a week, of which 15s. to 30s. will be absorbed by the extra staff required.

Trade Papers and Societies. The trade newspaper is, of course, the "Morning Advertiser." Weekly trade journals are "The Licensing World," published by the Licensed Victuallers' Central Protection Society of London, 35, George Street, Westminster; and "The Licensed Victuallers' Gazette," published at 81, Farringdon Street, London, E.C. Both journals

publish useful year-books. The Central Protection Society also publish pamphlets and booklets stating the publican's side in the many controversies affecting the trade. This and similar protection societies throughout the country look after the legal interests of publicans, conducting police-court and similar cases for their members. The Incorporated Society of Licensed Victuallers, in connection with which the "Morning Advertiser" was started, and the Licensed Victuallers' Asylum afford relief to distressed victuallers, and look after their interests.

MANICURISTS

The practice of manicure—probably in almost as complete a form as present-day treatment—comes to us from a period in the world's history as remote as the time of the Roman Empire. The Egyptians also affected some form of it, but in a ruder way—little beyond the shaping of the nails and staining with the pigments peculiar to this race. Such observations as can be relied upon point to the treatment being confined to shaping the nails in elongated form, and staining beyond the light arc circle. Possibly the cuticle also received attention, together with the removal of dirt and debris from under the edge of the nail; while the brightening and cleaning, and even the bleaching of this portion, may have formed a part of the Egyptian process.

Coming to later French history—say, during the Louis period—the art of manicure was well understood, and freely patronised. Marie Antoinette, with all her mystic aids to beauty, did not neglect it. The apartments and secret drawers in the boudoir furniture of this epoch, together with the peculiar chinaware and implements then in vogue, all bear evidence of the employment of this art.

Manicurists Abroad. At the present day the practice of manicure is probably more general in the large cities of the United States than anywhere else, though Paris and Berlin, and even Vienna, occupy prominent positions in this respect. To Paris should fairly be awarded the credit for the best work, although here, again, New York cannot be omitted from recognition. London certainly shows signs of advancement, but at present the number of practising manicurists in the English metropolis is meagre in comparison with the capitals of France and the United States. Performers of moderate skill and little experience are fairly plentiful. Obviously, it should be the aim of all who practise manicure as a livelihood to excel in ability, and there is more scope for individuality than may appear at first sight.

Treatment of the Hand. The shape of the finger nails, and their appearance on the completion of treatment, vary in different countries. In England, the true filbert is generally accepted as becoming and proper, and very handsome can the hands be made when thoroughly treated in this style. The cuticle is dressed down to an artistic bevel, the light arc accentuated, and the shell pink heightened in the centre of the nail, the extremity of the latter being imperceptibly bevelled clear of the quick, and showing, of course, the transparency of the outer end or edge. In the best style of manicure practised in England the polish of the nails, although equal in smoothness, lacks in brilliancy, and the tinting is much less pronounced than in the treatment on the Continent and in the United States. Probably it would be correct to say that in our own country the work done with the file and manicure knife is more in evidence than is the use of the nippers and polishing materials. In France and America, the reverse is the case.

Russians, Viennese, and Germans favour the elongated nail, or accentuated point, and also a distinct pink polish. Racial distinction may have some influence on shape, but certainly the two nationalities first-named, and in a somewhat less degree the Germans, cultivate the nail of narrow width, giving quite a pointed appearance. The pink tinting and glossy polish are also unmistakable. This style of treatment is affected, too, to some extent, in America—a fact which English manicurists should not overlook, although, as a general tendency, the English filbert is the mode that should be practised.

Operators and Salaries. Manicure is largely in the hands of women, but the highest exponents are men—chiefly hairdressers—who take up this branch and abandon their original work. It is largely a personal business, few assistants being employed for manicure alone. Excepting in the best establishments of the West End of London, and their equivalents in other capitals, the assistants are required to take their turn in other departments.

When manicure is practised by hairdressers' assistants, the commission they receive is usually 3d. in the shilling, but less in some instances. The girls are paid 20s., 25s., and 30s. weekly, with a commission of about 5 per cent. on the takings. There are some establishments which confine themselves exclusively to manicure and facial massage, and in such cases one or two rooms on a floor above the street level usually suffice.

Equipment. Manicure and facial massage (the latter is dealt with in a separate article) are nearly always undertaken in conjunction, and the same apartment is generally adapted for both. The proper equipment of the parlour embraces the following: A lavatory basin, costing from 45s., with the plumbing in addition, according to the circumstances of the apartment; a special chair for the patient's use, often made with a reclining back and fitted with cups in the arms, so that the hands may be moistened in the softening preparations, and otherwise prepared for treatment with the manicure appliances—such a chair costs from 45s. to 50s.; a stool for the operator, which can be purchased for about 2s. 6d.; and usually a portable standard lamp, fitted for electricity or gas (generally the former), for throwing a good light on the fingers, and costing from 7s. 6d. to 21s. If the lamp is adapted for electricity, the installation of the current may, of course, be a further item in the expenditure.

Ordinary manicure outfits are not costly, though some specialists have their own personally-selected tool caskets, at an outlay of anything up to £5 5s. The charges for treatment in the general category of shops are 1s., 1s. 6d., and 2s., while the best practitioners obtain from 3s. 6d. to 5s.

Beginners give time—three months or more—in return for tuition and experience, or pay £5 or £10 to be under well-known men. No wages are paid in either case. There is a good living to be made ultimately by those who really acquire proficiency and keep themselves versed in the best and latest methods of treatment.

MASSAGE SPECIALISTS

The particulars given here should be read in conjunction with the article on Manicurists, the usual practice being for massage and manicure to be undertaken as a joint venture.

There are two kinds of massage—manual and mechanical—the one being done by the hand, and the other given by a vibrating machine. The hand form is probably as old as civilisation, but mechanical massage is quite a modern acquirement in England, although it has been in vogue in America for several years. As a general and genuine remedy, there are many operators who claim that there is still no better method than the hand treatment. But against this there is the fact that the use of mechanical appliances is extending and attracting public favour.

Massage Treatment. Opinion is likewise divided as to correct procedure. Some experts hold that nothing beyond the creams, lotions, or oils should be used, while another section favour the steaming of the face in order that the pores of the skin may be first opened and the flesh rendered supple, and free to absorb the customary preparations. In most cases, the latter treatment is accomplished by hot towel bindings—that is, towels wrung out from quite hot water and wrapped round the face. Some operators, however, favour direct steaming. This can be done with appliances technically termed *vaporisers* (their effect is similar to that of a steam kettle on a smaller scale), or by holding the face over a vessel containing hot water.

Charges. Facial massage, as in the case of manicure, is usually a department of the hairdresser's establishment, the operator being paid a commission for this service in addition to his usual wage. The sum varies, but 3d. in the shilling is general. Outside a few of the West End London houses, assistants are not employed for facial massage alone. Young ladies as masseuses and manicurists are paid from £1 to £1 10s. per week and commission (about 5 per cent.).

The charges made for massage treatment range from 1s. 6d. to 3s. 6d., with 2s. as the average. In good class barbers' shops, where mechanical appliances are in use, gentlemen are treated for 1s. 6d., and for 1s. if only massage by the hand is given. In America, massage is far more general than in England, and is always done by barbers. The average charge is 1s. 6d., and 2s. if given by means of the vibrating machine.

The Massage Parlour. When an apartment is devoted to massage, it usually takes the form of an ordinary reception-room, with additional fittings as noted in the article on Manicurists. But massage for gentlemen is often given in the ordinary hair-dressing saloon, and the American haircutting chair, as illustrated in the article dealing with Hairdressers [page 3297], is then used. If mechanical massage is to be given, an electrical vibrating machine of the best make costs £25, and, of course, a supply of electricity must be in readiness for its working. As indicating what these vibrators are capable of doing, it may be stated that they are fitted with levers which can be shifted at will, producing vibrations to suit the operator's requirements, from one to seven thousand per minute. A portable electrical vibrator can be purchased for £7. There are also hand machines at about 30s. each, but these are usually intended for private use.

The conditions which govern the learning of the business and gaining an entry into it are similar to those described in the article on Manicurists.

MILLINERS

The word milliner is derived from Milan, a town which at one time gave the law to Europe in matters of taste and elegance, and which has always been noted for the excellence of its silks and velvets, so that, in course of time, one whose business it was to shape these materials into the different varieties of feminine head-gear came to be called a Milaner, or *milliner*. In former years the word appears to have had a masculine significance, but in modern times this is one of the trades in which women have managed to keep the monopoly, and in which they have been, on the whole, very successful. There have, of course, been a number of cases foredoomed to failure from the start. Within the past ten or twelve years there has been a great increase in the number of milliners' shops, especially in London, and a large percentage of these shops, after struggling for existence during a few years, have come to an inglorious end in the Bankruptcy Court. As a rule, the women of this country are far behind those of France and America in the conduct of commercial enterprise, and the reason for the majority of these failures may be found in the fact that many who possess *some* of the qualifications which make for success in millinery rush into this particular business without having had any practical experience, or without having undergone some preliminary training in the elements of shopkeeping. The result could hardly be other than disastrous.

Training. It is not difficult to obtain a thorough training in a comparatively short time, and at a reasonable cost, in one of the various schools of millinery which are now established in London and some of the chief provincial towns. At these schools the pupils receive instruction in the whole art of millinery. They are taught to make the wire shapes, to make French flowers,

to shape and plait the straw, and to copy with absolute accuracy the most elaborately-trimmed of Paris models. The course at The Studio (School of Dressmaking and Millinery), Artillery Mansions, Victoria Street, S.W., lasts for one year of three terms. The fees for the course in millinery and French flower making are £12, or for millinery alone, £6. At the end of that period, the pupils sit for the London Higher Technical Examinations, and diplomas are awarded to successful candidates. The examiners are drawn from education centres, and from different West End firms representing the trade. Having passed her examination, the intending milliner should spend at least six months in the work-room of a good house, and, if possible, should spend a short time in the show-room also, in order to obtain some practical knowledge of business methods. She should also know how and where to buy all chiffons, silks, and other materials, as well as how to take and keep stock; and, if her ordinary school curriculum did not include bookkeeping, lessons should be taken in that all-important branch of commercial education before she can consider herself ready to begin work.

Capital. With reference to the amount of capital which would be required to commence business as a milliner, it is not possible to fix any definite sum. Various considerations should be taken into account, such as the locality chosen for the start, the class of business to be done, and the character and capability of the individual. It may, however, be laid down as a safe rule, that no enterprise of this kind should be embarked on unless there is a sufficient sum of money in hand to purchase all the stock and furniture required, and to pay all working expenses for at least one year. The expenses to be allowed for would include rent, rates and taxes, lighting and heating, wages, and the stock for each season, in addition to all personal living expenses. Advertising should also be allowed for, and unless one had a large connection, a considerable sum should be spent in this way. A milliner, even more than a dressmaker, finds it profitable to keep a regular series of illustrated advertisements in two or three of the ladies' papers, and money should also be spent on tasteful circulars, printed on good paper, and showing illustrations of each season's hats, which should be sent out four times a year.

Starting in Business. Locality and position will probably depend upon the amount of capital available. The risk of failure is often less in a fashionable seaside resort, or a provincial town, than in London, where expenses are so heavy, and where competition is so keen. Too much care cannot be given to the artistic fitting up and furnishing of the rooms. The fashionable London milliner usually trades under a fancy name, such as "Monica," "Dolly Varden," or "Lucile." Her show-rooms are like handsomely appointed and luxurious drawing-rooms, with the softest of carpets, choice bric-a-brac, and Louis Quinze furniture; very little is there to show any connection with millinery, except a few hats, laid here and there, as if by accident, a few more on stands in the corners of the room, and deep oak drawers running all round the walls. The most private and expensive milliners are usually established up one or two flights of stairs, or, if on the ground floor, not more than two or three models are permitted to be exposed to the vulgar gaze, all exclusive designs being jealously hidden away under folds of tissue paper in boxes or drawers. The suburban milliner, on the contrary, pays especial attention to the dressing of her window, everything that is new and showy being displayed in order to catch the eye of the casual passer-by. In both cases, it will be necessary to spend a good deal of money on carefully selected models, although all materials should be stocked in as small quantities as possible, as they can be purchased from the wholesale houses when required. Unless the West End milliner starts with a large connection, she will obviously require a substantial sum for advertising, as her windows count for little or nothing in this respect. In addition to the usual stock-in-trade, ready-made blouses, lace, ruffles, scarves, etc., and sometimes *lingerie* and corsets are frequently sold by milliners. This is more than ever the case since the advent of the motor-car, which is said to be ruining the millinery trade. Where formerly four or five hats would have been sold, nowadays only one, and a few cheap motor caps and veils will be considered sufficient.

Practical Hints. One experienced assistant, costing from 16s. to 21s. a week, with two or three improvers at about 6s., will probably be sufficient hands to begin with, and when increase of business justifies the engagement of another assistant, she should, if possible, be a Frenchwoman, or, at any rate, she should have spent some time in France. In addition to the ordinary fashion journal and circular advertising, any plan which might suggest itself as likely to bring people to the show-room should be tried. In one case, a good connection was established in a very short time chiefly owing to the fact that afternoon tea was served to customers every day. The particular premises referred to happened to be unusually suitable, and the outlay and trouble involved were trifling, while the increase of custom was remarkable.

To make the business an artistic and financial success, it is not sufficient to possess only quickness of observation and the power to imitate and adapt, as well as the talent necessary to make a hat. To all this must be added the art of the saleswoman. It is all-important to remember that the great object, especially of the beginner, is not so much to sell a hat as to please the customer and bring her back to the shop, probably with a friend next time, if the first choice be something really suitable and becoming. Whether living in town or country, frequent trips to Paris should be made.

Continued

MUNICIPAL POSTS IN THE COLONIES

Openings for Teachers, Nurses, Engineers and Surveyors, and Medical and other Officers in British Colonies

By ERNEST A. CARR

WITH few exceptions, municipal activities are naturally far less developed in our Colonies than in the ordered and close-knit life of the home country. But as the townships overseas grow in size and wealth, and the need for some sort of public control becomes increasingly evident, a system of local government grows up apace—based for the most part on English models—and affords employment for an official staff. To select a few striking instances, such towns as Melbourne, Wellington, Cape Town, and Johannesburg enjoy a municipal system of local service as fully developed in many respects as that of London, and examples are not wanting of Colonial corporations with profitable undertakings in gas, electricity, and similar "municipal trading" ventures.

Openings for Englishmen. For readers in this country the greatest interest attaches to the practical question, "What demand exists in the Colonies for municipal officers from England?" It must be admitted at once, in reply, that the general position in respect of municipal employment closely resembles that described in our preceding article with reference to the Government service. The Colony itself, in a word, is usually able to meet its own demands for candidates.

But this rule is not without many exceptions. Owing mainly to the local lack of training facilities, the leading Colonial towns apply from time to time to English sources for suitable officers—and particularly for such skilled servants as school teachers, nurses, medical officers of health and sanitary inspectors, and municipal engineers and surveyors.

In such cases the selection of a suitable English candidate is usually entrusted by the corporation concerned to its agent in London, who advertises the vacancy either in an organ of the particular calling from which applications are sought, or in one of the weekly or monthly papers devoted to municipal affairs. Among publications of the latter class, that in which announcements of Colonial appointments most frequently appear is probably the "Municipal Journal," published at 12, Salisbury Square, London, E.C.

Public School Teaching. The department of public education, which in some corners of the Empire is in the hands of the responsible Government, but is generally controlled by urban or district authorities, affords greater scope for candidates from Great Britain than any other branch of the Colonial public services. Not that teachers from the Mother Country are in general request throughout the Colonies. In Canada, for example, although British qualifications are recognised, the supply of teachers trained within the Dominion is, except in the North-West Territories, ample for the vacancies that arise. The same is true of Queensland, New South Wales, and South Australia.

On the other hand, there are several Colonies in which a demand for educational volunteers from home occasionally arises, New Zealand and West Australia being instances in point. And in the South African Colonies, in particular, the dearth of qualified teachers occasions a constant request for outside applicants.

Prospective emigrants should remember, however, that the lack of local teachers often arises, at least in part, from the scanty remuneration offered by Colonial school authorities, and that the value of a salary is determined, not by its amount, but by its purchasing power. Western Australia is a case in point. On the Goldfields, and in other districts of the State, the cost of living is notoriously high, yet the average stipend of teachers is only £143.

Salaries of Teachers. The following tabular statement has been compiled to show approximately the range of salaries in those Colonies in which a substantial demand for British elementary teachers at present exists. Further details as to the prospects of Colonial teaching will be found in the invaluable "Professional Handbook" mentioned on page 3550.

SALARIES OF ELEMENTARY TEACHERS IN CERTAIN BRITISH COLONIES

District.	Principals.		Assistants.		Remarks.
	Male.	Female.	Male.	Female.	
	£	£	£	£	
South Africa:					
Cape Colony	250–420	160–350	120–350	80–240	Demand considerable.
Transvaal	300–500	300–400	150–390	90–300	Demand considerable.
Orange River Colony ..	250–450	150–225	150–250	90–200	Demand considerable.
Western Australia	80–450	70–350	80–220	60–200	Many vacancies in certain areas.
New Zealand..	60–375*	60–221*	100–245	80–205	Openings for well-qualified teachers.
N.-W. Territories (Canada)	130–280	80–175	100–200	65–130	Demand constant.

* With house allowance of £10 to £50

South African Appointments. Vacancies for science teachers and for instructors in special subjects, such as gymnastics or cookery, are occasionally advertised in the English educational papers. In such cases a second-class passage to the Colony is usually provided gratis, the selected applicant, in return, entering into an engagement for three or five years' service. The remuneration is fairly liberal; fully certificated women teachers of cookery, hygiene, or physical drill receive £130 to £180 a year, and the rates for male technical teachers are about double these figures.

In the absence of an agreement of this character, trained teachers in quest of employment in Cape Colony are recommended by the Emigrants' Information Office to arrange, if possible, for a friend in the Colony to apply on their behalf for any suitable vacancy that is advertised out there. They should also address a written application for an engagement to the Secretary, Education Office, Cape Town. And if a candidate sends a statement of his or her qualifications and experience to the Department of Public Education at Cape Town, it will be inserted in the "Education Gazette"—an official organ circulating among school managers and principals. British qualifications, it should be added, are recognised in the Colony. Teachers in the Western Province are required to be able to speak both Dutch and English.

In the case of female teachers—and these form the majority of the educational staff at the Cape—application for employment may usefully be addressed to the Educational Secretary, South African Colonisation Society, 47, Victoria Street, London, S.W. Those who desire to complete their training in the Colony as elementary, secondary, or kindergarten mistresses can obtain from the same Society particulars of the Training College for Women Teachers at Grahamstown, which is open under certain conditions to candidates from home.

Alike in Cape Colony, the Transvaal, and the Orange River Colony, the supply of trained teachers is still inadequate to the demand, and there are, therefore, good openings for qualified candidates. But women teachers, especially if uncertificated, should not go out to either Colony on the chance of securing an engagement unless they have friends with whom they can reside while seeking employment. They are recommended instead to seek the aid of the officials of the Emigrants' Information Office, on whose advice they may rely implicitly.

Teaching Posts Elsewhere. Degrees and training certificates obtained in the United Kingdom are accepted in Western Australia, where teachers are generally in request. But we have already mentioned as the chief cause of this demand the low salaries which fail to attract qualified officers. In view of the high cost of living, the maximum of £220 for assistant masters, and £200 for their feminine colleagues, is admittedly inadequate.

In New Zealand, although the average of salaries is scarcely higher, the expenses of living are far less, and there is consequently a good local supply of candidates. But well certificated British teachers are in request, and those who can await the occurrence of suitable vacancies may find excellent openings from time to time in the public schools of the islands.

Full information as to the prospects of employment in the Canadian North-West Territories may be obtained from the Department of Education at Regina. Masters and mistresses trained in England are first admitted on an "interim" certificate, and must teach in the Territories for a year before receiving a full "professional" standing. As a teacher's salary depends on the class to which he is admitted, candidates are recommended to ascertain from the Education Department before going out the standing to which their British qualifications would entitle them.

Public Nursing. The official handbook for emigrants contains a paragraph on nursing in the Colonies which, though not restricted to municipal nursing, summarises so justly the prospects afforded by that particular service that it merits quotation:

"There are occasionally openings in the Colonies for a few trained hospital nurses. There are Homes for providing trained nurses in some Colonial towns, but, as a rule, the Colonies do not offer any great attraction to nurses; the openings are not very numerous, and the pay is small as compared with that of other callings."

In nearly all British dependencies of every sort nurses who have been trained in the hospitals of the Motherland are readily admitted to practise, and have at least equal chances with locally-trained rivals in competing for appointments in the asylums and hospitals of the Colony. Such positions, however, are not often advertised in this country, and are generally secured by candidates who are on the spot.

Trained nurses employed in the public service in the New South Wales hospitals receive from £65 to £97 a year, without board and lodging, or £20 to £60 in addition to those allowances. This State possesses an Army Nursing Service Reserve, for which nurses are eligible between the ages of 21 and 40, provided that they have had three years' training in a civil general hospital. In Western Australia the rates of pay are £36 to £90 for nurses, and £50 to £150 for matrons, with food and quarters; but the highest figures are given only on the Goldfields, where all the necessaries of life are dear.

In the municipal and Government hospitals of South Africa the remuneration is also generally high. Trained nurses receive from £60 to £95 a year, and matrons £100 to £180, in some instances with free quarters and washing. British hospital nurses in quest of appointments under the Rhodesian Administration should apply for terms to the London office, 2, London Wall Buildings, E.C. Applications for an engagement should be addressed to the Medical Director at Salisbury, Rhodesia, enclosing duly certified copies of certificates and testimonials.

Asylum Staffs. Nurses in lunatic asylums in Australia are paid from £35 to £75 a year, with free quarters and rations; and

matrons generally between £100 and £160, with similar emoluments. The rates for asylum warders in the Commonwealth vary considerably in the several States, the highest pay being in Western Australia (£90 to £150, with quarters and rations) and the lowest in Tasmania (£60 to £80, with a like allowance). Candidates for posts as nurses or warders in Victoria must be between 21 and 40 years of age.

In South Africa the remuneration of asylum officers, in addition to full or partial allowances, ranges within the following limits: Nurses, £40 to £75; matrons, £85 to £150; and warders £50 to £120. Salaries are generally lower in the asylums of Cape Colony than in those of the other South African territories.

Although in strictness a private and voluntary movement, this Association has now been accorded a semi-official footing, by the action of the Colonial Office in employing it as the chief source from which nurses are drawn for Government service in the Crown Colonies. Apart from its most useful efforts in the direction of private nursing, the Association is thus in the position of an agency for State employment, and as such should be mentioned in our columns. The trained nurses furnished by this organisation to the Colonial Government are employed chiefly in British West and Central Africa, Ceylon, Hong Kong, the Malay States, the Straits Settlements, and the West Indies. The term of service is usually either three or five years. Nurses seeking an engagement of this nature should apply to the Hon. Sec. of the Association, Miss Mowbray, at the Imperial Institute, London, S.W.

Engineering and Surveying Posts. The prospects of British engineering experts outside their own land is considered in the course on Civil Engineering, and it is necessary to add but a few words on the municipal side of their profession—which is generally less remunerative, by the way, than private practice.

Colonial engagements as municipal engineer or surveyor are not often available to candidates in this country. The exceptions occur when a very responsible position has to be filled—such as the chief surveyorship of a growing city—and there is a dearth of local candidates of the requisite experience. Vacancies of this class are announced in the English engineering journals as they arise. Minor appointments are usually made from among applicants in the Colony.

British qualifications, however, are widely recognised, the M.Inst.C.E., in particular, being as valuable in the Colonies as in this country. In Victoria, corporate members of that Institute, and those who have passed the examination of the Association of Municipal and County Engineers are eligible under certain conditions for appointment as municipal surveyors, and as such may undertake the construction of roads and bridges for the local authorities. On the other hand, the Lands Survey branch of the State Service is recruited mainly by surveyors trained in the department itself.

Apart from professional posts in technical colleges, the Colonial municipalities afford but few openings for chemists. The most important corresponds with the position of public analyst in an English borough. In the Canadian Dominion such officers are required to pass an examination in chemistry and microscopy. Analysts to local authorities in New South Wales must be approved by the Board of Health, which in future will recognise only the Associateship and Fellowship of the Institute of Chemistry; and the Victorian Health Board, which has similar powers, is scarcely less exacting. In many other parts of the Empire, however, the detection of adulterated food supplies has not become a pressing matter, and thus the field for local government analysts is still very restricted.

Other Offices. Other vacancies for municipal officers of various grades in the Colonies are announced from time to time in the English Press—generally on terms sufficiently high to attract fully competent candidates. Thus, for the positions of treasurer and assistant treasurer to a leading South African corporation, the respective salaries of £1,500 and £600 were lately offered. Medical men possessing the public health diploma, and willing to sign a three years' agreement, were invited by the agent of a Natal municipality to apply for the appointment of medical officer of health at a salary of £650 a year, rising to £750, with a first-class passage out. Again, a vacancy as chief of a corporation fire brigade in Cape Colony, with a remuneration of £600 yearly, and free quarters, was recently advertised in this country. It may be added that this post was secured by a candidate who, as the head of a considerable English fire force, had been in receipt of a salary of £130.

Such instances serve to show that a well-qualified and fortunate municipal officer may rapidly advance his ambition by emigrating. But there is no Royal road to such advancement. Suitable vacancies are rare and eagerly contested, and there may be long waiting and many disappointments to endure ere the aspirant ultimately attains success.

A Last Word. In concluding with the present article our survey of the Imperial section, we complete also that greater subject of the Civil Service of which this forms part. As we have sought to show, the Civil Service of the Empire is of unmatched variety and extent, affording scope in one or other of its three divisions—Municipal, National, and Imperial—for the most diverse talents and ambitions; and the liberal though not extravagant rewards of each section are available, without let or hindrance, to men of the requisite abilities. We may, perhaps, be forgiven for emphasising anew, in conclusion, the qualities that make for success. They are, firstly, a sound training, and lastly, strenuous and thorough work. In the Civil Service, as elsewhere, there are some incompetents and many mediocrities. But the men who succeed—the men who "run through the ruck" and win the prizes of the Service—are they whose keynote is Efficiency.

Civil Service concluded

Group 9
DRESS
26
Continued from page 3591

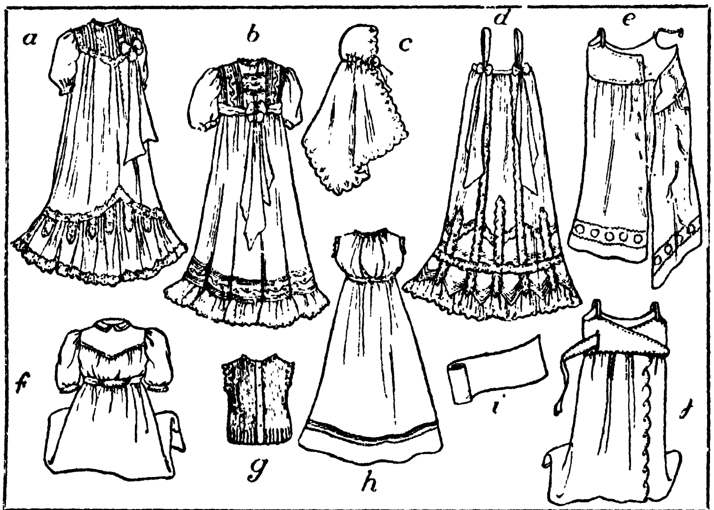
CHILDREN'S CLOTHING

Suitable Material for Infant Wear. The Layette. A New Hygienic Set. Stitches and Methods of Sewing Employed

By AZÉLINE LEWIS*

THE clothing of an infant should be light, warm, and easily put on; tightness of any kind and heaviness are unhealthy and unwholesome. All hard seams and ridges should be avoided; the fewer seams there are in a garment the better, whilst all armholes should be loosely fitting.

Materials for Baby Wear. As to the material, medical opinion is unanimous that it should be woollen, preferably all through. Dr. Gordon Stables says: "The woollen garments may be as light as you please, but let them be wool. Wool keeps up the warmth more equally, and, if light, it does not 'plot' the skin. Cotton cools down too soon, and, indeed, it may get cold while still wet with perspiration. The animal heat of the body is carried away too rapidly, and a chill to the delicate frame is the inevitable result."



1. THE LAYETTE

Flannels, and woollen materials too, are now made in such beautiful qualities, and of such fine makes, that there need be no fear of the little one not being daintily clad. Cambric and lace may, of course, be used, but such things should only be employed for the over garments, as frocks, petticoats, pinafores, slips, skirts, etc.; nothing stiff or starchy should come near the face, neck or hands.

In baby attire simplicity and daintiness should be the essentials; the wee mite wants to kick and move its arms freely, and not become tangled up in a mass of meaningless frills. As a baby should spend the first months of its life in sleep and much of the first period of its existence on its back, it follows that no ribbons or strings should be tied here to cause pressure on the spine. Further than this, the ideal baby garments should all fasten either in front or at the side, never at the back, as no matter how soft the ribbon, how small the bow or buttons, these must cause pressure and irritate the soft and tender flesh.

Layette. A layette, like a trousseau, varies, of course, in the number and quality of its component parts, according to means and circumstances. There are, however, certain things which are indispensable to any baby's comfort and needs, the numbers of which may be added to with great advantage, whilst the cost and fineness of the materials with which they are fashioned can be increased accordingly.

The following, then, may be taken as a fair list of the least number of articles required for a layette:

2 Binders	3 Pilchkins
4 Woolly vests	3 Head flannels
4 Long flannels	1 Small soft shawl
6 Day gowns	1 Large shawl for outings, or a long cloak
4 Nightgowns	
4 Petticoats	
2 Doz. Towels	

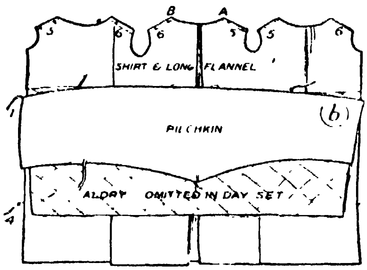
2. GARMENTS FOR THE "NEW BABY"

Bibs, bootees, gloves, veils, are all accessories for which no list can be given. For a town baby two silk skirts will be found very useful to slip on over the day gown, when it takes its everyday outing, whilst a little silk or cambric teagown is a very delightful addition to baby's wardrobe, in which he can be smartened up in a few minutes, without changing.

The ideal shape for this garment is the Aliône which set is referred to later on.

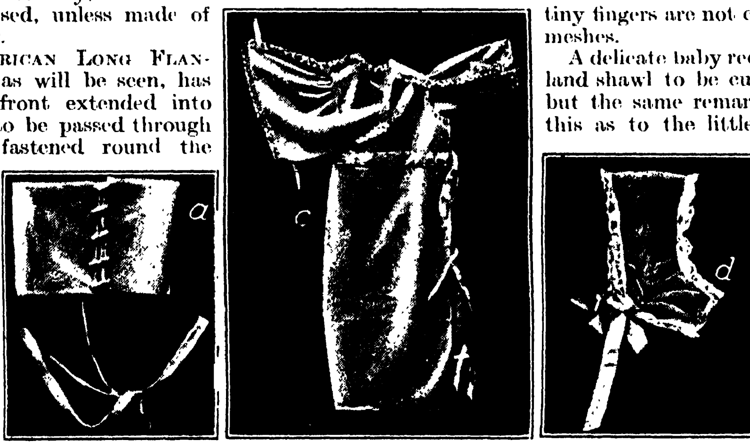
The Garments. Fig. 1 shows the various garments of the usual shape:

THE BINDER. This consists of a straight piece of flannel, 5 in. or 6 in. wide and about 27 in. long, or more. It should be simply torn off and left raw-edged, and then there will be no ridge to press on the baby's body (*i*).



THE VEST. The vest should be of the finest wool, opening in front, as it will be easier to put on, and there is less risk of twisting the little arms (*g*). If the idea cannot be abandoned that baby is not properly clothed without the shirt, this can come next, but is quite unnecessary, and is very little used, unless made of nuns' veiling.

THE AMERICAN LONG FLANNEL. This, as will be seen, has the bodice front extended into points, one to be passed through a slit and fastened round the body (*j*). There is another long flannel of somewhat simpler shape, which has the advantage of being equally useful during the short-coating and later periods by merely shortening the skirt. Note that the shoulder-straps fasten over in front and are of fairly good width, narrow tape being likely to cut and hurt the infant (*e*).



3. THE ALIÔNE SET

THE PETTICOAT. As to the petticoat, there is a slight diversity of opinion about it, some holding it to be necessary and others not, but a woollen-clad baby's wardrobe would not contain it. It is usually made of fine longcloth, lawn, cambric, or linen, tucked and trimmed according to circumstances. It should be only very loosely gathered round the neck (*h*).

THE DAY GOWN. This may be of cambric, fine hair-cord muslin, gauze flannel, nuns' veiling, or Japanese silk, the last being preferred by many, as it is soft and washes so well. Trimming and materials are, of course, matters of taste (*b*).

THE NIGHTGOWN. The nightgown should be of Viyella, gauze flannel, fine white wincey, or nun's-veiling. The pattern is the same as that for the day gown (*f*).

EMPIRE GOWN OR ROBE. The robe can be as smart as possible, the little bodice being formed of strips of insertion and tucking (*a*).

THE HEAD-FLANNEL. This should be a sensible square of fine flannel, 36 in. or 45 in. wide, not the small thing usually made, which is always slipping off. One corner is rounded off, and has a casing run round to form a hood, as the sketch shows. This should be large enough to go over the head comfortably (*c*). A crochet or knitted shawl answers this purpose equally well, if not better, provided it is of a close make, so that the tiny fingers are not caught in the meshes.

A delicate baby requires a Shetland shawl to be cuddled up in, but the same remark applies to this as to the little head shawl with regard to the make.

SILK SLIP SKIRT. Fig. 1 (*d*) shows this skirt, which has been already referred to. With respect to the out-of-door attire, a woollen shawl, of firm, close make, is really better and warmer for a baby than the usual long cloak, unless this be made with sleeves to protect the arms and hands.

4. OUTDOOR GARMENTS

A little knitted hood is worn by both boy and girl babies for the first few months, but head-gear is mentioned later.

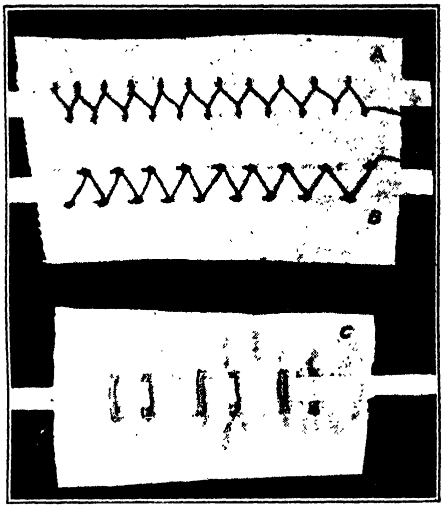
As to the towels, of which several dozens can well be added to the list, these may be of birdseye or other diaper, but the best are good-sized squares of turkish towelling, which can either be bought ready-made, or made from the wide make of this material sold by the yard. It can be left raw-edged, or simply overcast loosely with soft cotton, as a hem makes a ridge which is likely to hurt, and is not advisable.

The next diagrams show the revised editions of baby garb, by the aid of which he can be dressed in five minutes, or less, without any twisting or turning at all.

Fig. 2 shows the few and simple garments required by the "New Baby." The binder, consisting of two strips of flannel (c), the inner one longer than the outer; the little woolly vest and the revised long flannel (a). This is cut with armholes and sleeves extending to the shoulders, obviating the tightness of the usual shape, and avoiding the objectionable practice of bending back the infant's arm, which is necessary with the round arm opening. The same pattern will do equally well for the small nightgown, for which the sleeves will be a little fuller, and a little ornamentation added, according to taste, either by feather stitching, lace, or embroidery.

The long sleeves make a flannel vest or barrow coat unnecessary, whilst the skirt portion, being buttoned to the bodice, makes a frequent change possible without undressing the baby.

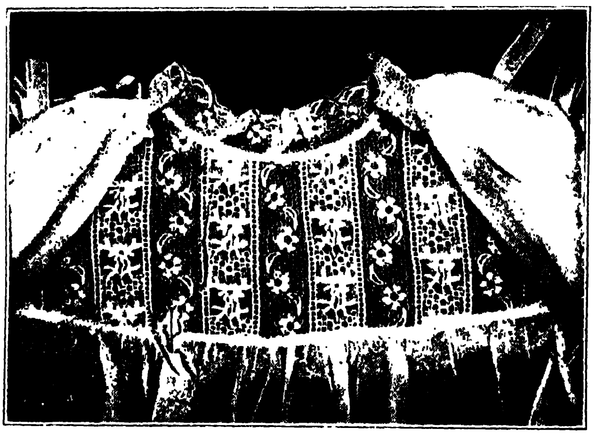
The little pilchkin is an addition which mothers and nurses will appreciate, its object being to prevent the towels slipping off. It is made either of flannel or bath towelling, and is merely a long, narrow strip of the material tapering off to a point at one end, the broad end being secured by a button or safety-pin to the back of the long flannel, the point being brought up and fastened in front, either to the long flannel or the binder.



5. RIBBON INSERTIONS

Fig. 2 (b) shows a Princess day or night gown, as the pattern will do for either. It could be made of dainty woollen or cotton goods, as preferred. This shape fastens over at the left side, the back being plain and seamless.

Fig. 2 (d) shows another shape of nightdress of most delightful simplicity. It can be cut all in one piece, or to fasten at the side, and for the vaccination period will be found invaluable.



6. TRANSPARENT YOKE

In Fig. 3 we have the ideal baby garments, known as the *Alión*, but as they are registered, the patterns can only be obtained from the inventor.

In these, as in the others just mentioned, a baby can be dressed in from three to five minutes, each garment being placed in its proper position, and the baby last, when they are fastened as shown, by tapes and buttons only, without once moving the child. The sleeves, it will be seen, button down the side of the arm. (a) shows the binder; (b) the set ready for putting on; (c) the nightdress; (d) the ear cap to prevent prominent ears. The "softie" pilch belonging to this set, and brought out by the same lady, is the most comfortable thing ever invented for a baby's underwear, and should be in every baby wardrobe.

Fig. 4 illustrates some other garments necessary to the baby's comfort: (c) shows a square kimono; (d) a circular one; and (b) a tea-jacket or outdoor coat. The two first should be of woollen material, whilst the last one may be more elaborate.

Fig. 4 (a) shows the cloak, which, it will be noticed, is cut with sleeves, and is of ample fulness. (c) illustrates a hood cut all in one, the shaping being done by means of darts. This can be fastened to the cloak and all be put on together. A knitted woollen hood or hat, however, is equally warm and comfortable. The cloak can be of cashmere, Oriental satin, or Bengaline interlined with domette; the lower cloak should be lined with nuns' veiling, and the upper ones with silk.

The Making of the Garments. The actual making of baby garments is simple, but the workmanship should be of the finest and best, whether it is done by hand or machine.

For the sleeves of flannel garments it is far better, for obvious reasons, that they should not be set into a band, but drawn up by ribbon run through fancy stitches worked outside. Fig. 5 shows three ways of accomplishing this. The third merely consists of perpendicular buttonholes, and makes a little more work than the two upper ones. It is especially suited to the head-flannel shown in Fig. 1.

Insertions should always be transparent, whether for bodice, cuffs, or lower part of skirt. Fig. 6 shows a transparent yoke of cambric insertion and lace, and the method of finishing off at neck and lower edge.

Continued

ELECTRIC OSCILLATIONS

Conditions for Oscillation. Mechanical Analogies. Oscillating Electric Sparks. Resonance

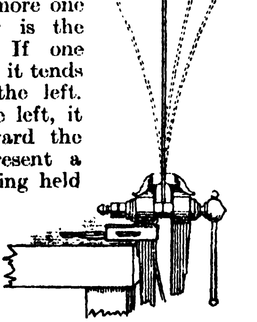
Continued from page 3581

By Professor SILVANUS P. THOMPSON

OSCILLATION, in its mechanical sense, is the name given to a repeated to-and-fro movement like that of a pendulum or a vibrating spring, or to the movement of a shuttle in the loom. If a pail full of water be set down upon the ground with a jerk, the water in it oscillates from side to side of the pail, the movement gradually subsiding till the water comes to rest. Electricity, too, can oscillate, as we shall see ; and electricity in oscillation possesses certain peculiarities which are different from those of electricity at rest, or of electricity flowing steadily.

Mechanical Oscillations. The most obvious type of natural oscillations is furnished by a pendulum, consisting of a weight hung on the end of a thin string which, if drawn on one side and released continues to swing with periodic regularity. Another simple example is that of a loaded spring. If we take a long, thin strip of steel, such as is used for clock springs, or for busk steels, and fix a bit of lead at one end of it, and clamp the other end in a vice, then if we give it a push on one side it will immediately be set swinging, oscillating from side to side until it comes to rest. Some people would describe these to-and-fro movements of the pendulum or of the spring as *vibrations;* others would describe them as *oscillations.* It matters little what name we give to them provided we understand why they occur.

Forces of Restitution. The first thing to understand is that oscillations never occur unless there are forces that tend to restitution. That is to say, there must be present forces which tend to bring back the oscillating body, whether pendulum or spring, to its initial position. Everyone knows that a spring, when bent, will fly back, having forces of recoil. The more one bends it, the greater is the force of its recoil. If one bends it to the right it tends to fly back toward the left. If one bends it to the left, it tends to fly back toward the right. Let **225** represent a piece of stiff steel spring held upright in a vice, and having a lump of lead screwed tightly to its top. When at rest it stands upright, with its top at A. Suppose that we now exert a force sideways tending to bend it to B. The amount of force needed will depend on the stiffness of the spring and on the amount of the displacement or distance from A to B. Suppose the spring were so stiff that a force equal to the weight of an ounce, when applied at the top, would push it aside by 1 in., then to push it aside 2 in., to C, would require a force equal to the weight of two ounces. When pushed aside to B the force tending to restitution would be one ounce ; when pushed aside to C the force tending to restitution would be doubled. This is in accordance with the simple law of elasticity, that the force tending to restitution is proportional to the displacement.



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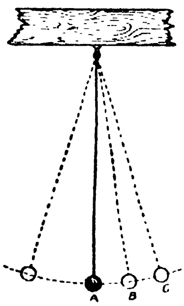


226

A similar law governs the movement of the pendulum. Let **226** represent a simple ball of lead hung by a thread from a hook. If one sets it swinging, the ball swings along the arc of a circle ; it swings to and fro along a curved incline, being constrained to keep in that path because it is tied to the hook as a centre of motion. Let its position of rest be called A. Then by applying a side-way force one can displace it to B. But if pushed to B and released it will not stay at B. It immediately moves back again to A. The force tending to restitution in this case is not elasticity, but gravity. The earth pulls it downwards ; but as it is constrained to move along the curved path only a certain resolved part (depending on the steepness of the incline at B) acts as a force urging it back toward A. If we give it a displacement twice as great, to C, it experiences a force of restitution almost exactly twice as great as it did at B, because the steepness of the incline at C is almost exactly double the steepness of the incline at B. So here again we find that the force of restitution at any point along its path is (approximately) proportional to the displacement.

Inertia. But everyone knows that the pendulum, when displaced aside from A to B or to C and then released, when it returns to A does not stop there but swings on beyond to almost an equal distance on the other side, and then comes back again. Why should the pendulum swing thus ? If the forces of restitution are zero at A, why does the pendulum, on returning from B, swing on past A ? The answer is undoubtedly to be found in the property called *inertia.* Every mass, whether of lead or any other material, when it has been set into motion, tends to go on moving. Every

moving mass, as explained on page 290, possesses energy of motion, also called *kinetic energy*. When the pendulum bob was pushed aside it moved a little up the incline, and in doing this work some energy was spent upon it. That energy thus given to it, it transforms, as it descends the incline, into energy of motion, which energy is still in it as it flies through the point A ; and it expends this energy by climbing up the inclined curve on the other side to an equal height. As it comes down again, it again gets up speed, which will again, because of its inertia, carry it up once more to B or C. And so it oscillates backward and forward, the energy given to it during the first displacement being transformed into kinetic energy as it comes down, and retransformed into potential energy as it goes up the curve.

It is similar with the loaded spring. In bending the spring, we give it potential energy [see page 289], which, during the recoil, is transformed into kinetic energy, the power of the spring being employed in putting the leaden mass into motion ; and the inertia of the moving mass carries it back past the point A, and it flies over to the other side, retransforming the energy of motion into the potential energy of the bent spring.

Necessary Conditions for Oscillation. We see, then, that the necessary conditions for mechanical oscillation are two in number: there must be (*a*) forces tending to restitution ; and (*b*) inertia. Further than this, a very few experiments will convince us that the frequency of the oscillations depends on both these things. For, consider the spring [**225**] already described. It has a certain stiffness, and it is loaded with a certain mass. If we make it stiffer (by shortening it, or by substituting a thicker piece of steel of the same length and quality), it will recoil more quickly, and the frequency of the springs will be increased. If we make it weaker (by lengthening it, or by substituting a thinner spring of the same length), it will oscillate with slower swings. Or, again, if, keeping the stiffness unaltered, we load the spring with a heavier mass it will swing more slowly, and the frequency of the oscillations will be reduced. The exact rule governing the matter is that *the square of the frequency is directly proportional to the stiffness of the spring and inversely proportional to the mass.*

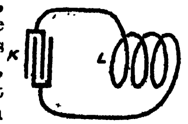
Decay of Oscillations. Any vibrating spring or pendulum will gradually come to rest, the amplitude of the oscillations gradually decreasing until the motion dies out. This is because of friction. There is friction at the point of suspension, if the pendulum rocks about a point, or in the cord if it has to bend where it is tied up. There is internal friction in the bending part of the spring. Also both the pendulum and the vibrating spring stir up the air in their movement, and waste a fraction of their energy in fluid friction at each swing, so that at each recurrence of movement the amplitude of the swing is a little smaller than it was at the previous swing ; and this waste of energy by friction, however slight, will gradually cause the motion to decay and the oscillations to die away. The time taken for the amplitude to die down to half of its initial value may be regarded as a measure of the rate of decay. If the swinging part presents a large surface to the air, it sets up much air friction, and the oscillations will be quickly damped out.

Production of Electric Oscillations. Now, what is true about mechanical oscillations is true—by physical analogy—of electric oscillations. In order that electricity should oscillate at all, the system must fulfil two conditions: There must be (*a*) electric forces tending to restitution ; and (*b*) something acting as electric inertia. We must inquire what these things can be.

In the last article [page 3579] we saw that when a condenser is charged it tends to discharge itself. While an electric current is being forced into it its potential rises, and the greater the charge given to it the more powerfully does it react, tending to drive the charge out again. In fact, the layer of dielectric in a condenser, whether glass, mica, or air, acts as if it possessed electric elasticity. The larger the area of its coated surface, and the less its thickness, the more easily is it charged. The thicker the dielectric and the smaller the area, the more stiffly does it react. The forces of restitution which it offers to the operation of charging are inversely proportional to its capacity, and directly proportional to the charge that is in it, and they are electromotive forces, not mechanical forces.

Further, it was pointed out on page 1362 that whenever a current has to flow round a coil or spiral so that it does some magnetising there is a reaction due to the interlinkage with the magnetic lines. This reaction manifests itself during the time when the current is growing by causing the current to grow more slowly—in other words, by producing a lag. It has another effect on a current that is dying—namely, that it opposes the diminution of the current, and keeps it flowing even after the electromotive force has ceased. This reaction, caused by the magnetism of the circuit itself, is termed *self-induction*, and it is purely conservative. It opposes all change. When the current is growing, it opposes growth ; when the current is decreasing, it tends to keep it up. The effect, then, of the presence of self-induction in a circuit upon the flow of the current is exactly analogous to the presence of inertia in mechanical systems. Judging, then, by analogy, we should expect *electric oscillations* to arise in an electric circuit if that circuit fulfilled the condition of containing (*a*) a condenser, and (*b*) a magnetising coil. In other words, there must be in the electric system both capacity and self-induction.

Oscillating Electric Sparks. Suppose that we take a condenser, consisting, as described in the last article, of glass plates between sheets of tin foil, and join it up in a circuit along with a self-induction coil. Fig. 227 represents such



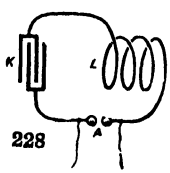
227

a circuit, K being the condenser, and L a self-induction coil made of a number of turns of insulated copper wire wound on a suitable wooden frame as a bobbin. Such a circuit is suitable for electric oscillations, and the frequency of them can be calculated if the capacity and self-induction are known. The formula is:

$$f = 1 \div (2\pi \times \sqrt{KL});$$

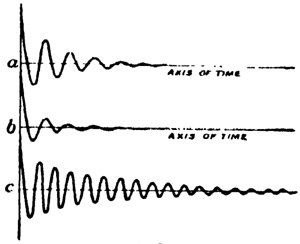
where f is the number of oscillations per second, K the capacity in *farads*, and L the self-induction in *henries*. Thus, if the capacity be 10 *micro-farads* (that is, $\frac{1}{100000}$ of a *farad*), and the self-induction is $\frac{1}{10}$ *henry*, the frequency will be 1,591 oscillations per second.

But although such a circuit may be adapted for electric oscillations, and have in this sense a frequency of its own, the difficulty will be to set up any oscillations in it. For many years it was not known how to set up such oscillations. What is wanted is some electric operation that will correspond to the operation, in the mechanical analogy of the loaded spring, of producing a displacement and then letting it go. For this purpose the circuit must be provided with a gap, as shown in **228**. The wires at the two sides of the gap should be furnished with brightly-polished metal balls set about $\frac{1}{4}$ in. apart, and connections should be made as shown to some suitable high voltage source such as an influence machine or an induction coil capable of giving sparks. Then what happens is this: The current running in from the source charges the condenser, and gradually raises the difference of potentials between the two balls until the air insulation between them breaks down and a spark occurs at the gap. This spark will be noticed to be bright and noisy. It really consists of a whole series of sparks oscillating rapidly to and fro.



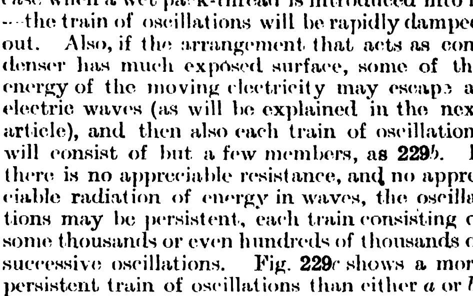
228

Nature of Oscillating Sparks. Half a century ago Lord Kelvin predicted from mathematical considerations that the dicharge of a Leyden jar through a wire coil would be oscillatory. Some years later Feddersen proved it to be so by observing the spark in a revolving mirror, when it was found to consist of a number of separate sparks that rushed in rapid succession across the gap in alternate directions. The necessity of the gap was pointed out in 1875 by the present writer. The explanation of the oscillations is as follows: As the condenser is more and more charged, its electric elasticity tends to drive the charge back more and more, until the moment comes that the insulation at the gap breaks down. Then comes a sudden surging of electricity out of the positive coating of the condenser, rushing along the circuit across the gap and into the negative coating of the condenser. But because of the self-induction of the circuit this rush of electricity goes on after the condenser is empty, and in so rushing on charges it up the other way. Then comes a rush back across the gap in the converse direction, and so backwards and forwards. The nature of an electric oscillation may be indicated graphically by the diagram **229***a*, in which the horizontal distance represents time, and the vertical distances the charge, positive or negative. The whole series of surgings begins with a sudden rush, followed by the subsequent alternations at a regular frequency. But each rush is feebler than the preceding one, and they die out, just as mechanical vibrations do. If the circuit offers a high resistance—as, for example, is the case when a wet pack-thread is introduced into it—the train of oscillations will be rapidly damped out. Also, if the arrangement that acts as condenser has much exposed surface, some of the energy of the moving electricity may escape as electric waves (as will be explained in the next article), and then also each train of oscillations will consist of but a few members, as **229***b*. If there is no appreciable resistance, and no appreciable radiation of energy in waves, the oscillations may be persistent, each train consisting of some thousands or even hundreds of thousands of successive oscillations. Fig. **229***c* shows a more persistent train of oscillations than either *a* or *b*.



229

Resonance. If two circuits be constructed as to capacity and self-induction so that they have the same natural frequency, they are capable of resonating one to the other—that is, if electric oscillations are set up in one of them, it can induce oscillations in the other. Sir Oliver Lodge has shown some exceedingly beautiful experiments on this plan with two circuits, which were *tuned*—that is, brought into syntony with one another. Let K_1 and L_1 [**230**] represent



230

a capacity and a self-induction coil of a circuit having a spark-gap at A, connected with wires to a suitable charging source such as an influence machine. Let the second circuit be arranged with capacity K_2 and self-induction coil L_2, and a spark gap B. The two must be tuned by altering either K_2 or L_2 until the condition is attained that $K_2 \times L_2 = K_1 \times L_1$. Also, the two self-induction coils must be put near each other so that they can act inductively (like primary and secondary of a transformer) on one another. Then, whenever a spark is made at A in the one circuit a spark will occur also at B in the other circuit. But if the timing be spoiled by having L_2 either too great or too small, then there will be no sparks at B. Sir Oliver Lodge showed this experiment with two Leyden jars and two simple semicircular arcs of wire.

Continued

Group 11

CIVIL ENGINEERING

26

RAILWAY CONSTRUCTION continued from page 3616

TRAMWAY CONSTRUCTION

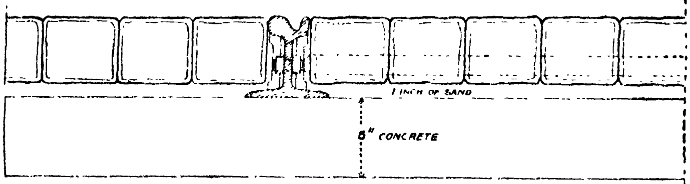
Utility of Tramways. Bed, Rails, Rail Joints, Crossings, and Paving. Tramway Construction Costs

By R. W. WESTERN

THE distinction between a tramway and a railway is hard to define. The word *tram* first appeared in the engineering world as the name given to a sort of waggon used for coals, and a tramway was a *way* for such a waggon. Historically, tramways came first, and the railway is, in fact, a development from the tramway.

The first tramways were rails of timber laid from various collieries to the nearest wharf exactly straight and parallel. As the wood was quickly worn by the rough traffic, wooden rails were nailed on the top of the others, and could be easily detached and renewed as required. Then wrought-iron laths were introduced for the like purpose, but without much advantage to economy on account of the high cost of the metal.

The First Tramway. In 1767, from some adventitious circumstances, the price of pig iron became very low, and the Coalbrookdale Iron Company, in order to keep their furnaces in, thought it would be the best means of stocking their pigs to lay them on the wooden rails, as this would help to pay interest, by reducing repairs of the rails, and if the price of pig iron rose, the pigs could be taken up and used as cast iron. This is a good illustration of how the development of the construction of ways of communication is governed by the relative cost of materials.



71. SECTION OF TRAMWAY SURFACE AND RAIL

With the invention of the steam locomotive, which required a road to itself, tramways almost disappeared from this country. They were no longer wanted for the collieries, and on the ordinary roads the public would not have them.

In America, however, where ordinary vehicular traffic was but meagrely developed, tramways grew up freely, and underwent many modifications and improvements as the use of iron and steel increased. They were introduced into English cities by an American engineer, Mr. G. F. Train, during the 'sixties, in spite of great opposition.

What is a Tramway? As now used, the word tramway may mean a light, temporary railroad used by contractors for various purposes; a permanent railroad of narrow gauge within the precincts of a factory or colliery; or a railway laid level with the surface of an ordinary road, so that other and unadapted vehicles can move freely over it and across it. In the United States of America, however, the last of these is more commonly described as a *street railway*, in many respects a preferable term.

A tramway will generally, therefore, differ from a railway mainly in the following respects—lighter loads, slower speeds, more frequent service, sharper curves, and steeper gradients. All these have modifying effects upon construction.

Street Railways. The design of these must provide that the special rolling stock will be confined to the rails, while all other vehicles are free to move on and off. An infinity of devices have been proposed and tried to effect this object economically. By process of survival of the fittest, the form of rail shown in **73** is now most generally used, together with wheels having flanges on the inside as described for rolling stock of railways.

Unsettled Ground. In cases where a tramway must be laid upon ground which cannot be relied upon to sustain the traffic permanently, it is best to adopt the sleeper construction, as for an ordinary railway Then, when and as th settlement proceeds, th paving of th road may b taken up an the level of th rails raised by packing more ballast beneath th sleepers.

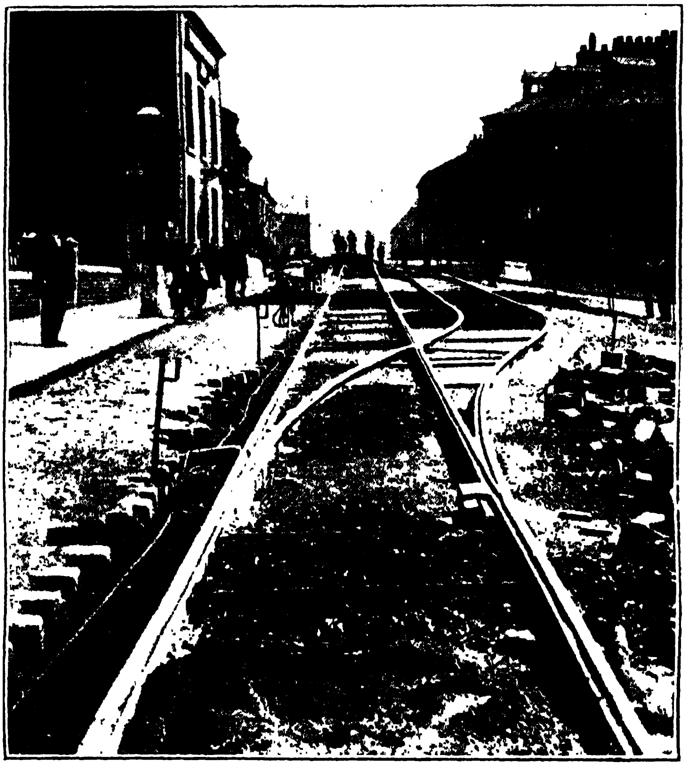
Usual Construction. Under ordina circumstances, the rails are laid upon a bed concrete about 6 in. thick, more or less, as co ditions require [71]. The photographic repr duction [72] illustrates a tramway line und construction. It must be seen, however, th the concrete itself rests on a solid, compact foundation, so that it shall not be subject to irregular cross strains sufficient to ca cracks. The concrete may be fortified introducing iron rods into the lower lay while it is being put in. Such rods may be ½ or ⅜ in. in diameter, and laid both longitudina in the direction of the rails and transvers to them. In this connection the articles reinforced concrete [pages 1554 and 1643] sho be consulted.

This rigid method of construction is v suitable to the streets of towns, but, as read

of the foregoing will readily appreciate, it is possible only on account of the comparatively light loads and slow speeds to which the tramlines are liable. And already in cities where the speed and weight of the tramcars are more than the average, its disadvantages are becoming apparent. It suffers much from the hammering effect of the wheels, and immediately any part is loosened, the hammering or pounding becomes aggravated at that place, rapidly causing destruction of the part. The introduction of wood between the rails and the concrete is therefore desirable where heavy traffic is anticipated in order to provide sufficient "give" to absorb the shocks.

The concrete may consist of four parts broken stone, two parts sand, and one part cement. The chief advantage of concrete beneath a street is that a uniform profile is more easily maintained upon the surface, which assists drainage and has the good appearance which the public demand.

Laying the Rails. The setting of the rails upon the concrete may be done in several ways. After the concrete is set it will always be found that the surface is not true enough to enable a rail to be simply placed upon it. The concrete may therefore be laid within a short distance of the level of the base of the rail and the intermediate space—say an inch — made good by blocks or wedges. Then, when the rail is in position, the space may be completely filled in with fine concrete. In places where the concrete is unduly high this is not always easily done, and then there remains but a thin, imperfect layer of cement, very liable to crumble under the traffic.



72. CONSTRUCTION OF A TRAMWAY

Granite chips are sometimes introduced to fill the space, or the rails may be placed first in their correct positions, and held by temporary supports, while the concrete is put in beneath them and carried up over the base of the rail, so as to include it. To effect this the concrete must be rather wet, and care must be taken that it is well worked in beneath the rail and smoothed off before it sets. If wood be used as a cushion beneath the rail, the laying of the concrete is done in the same way, except that it is seldom carried above the level of the bottom of the wood. The wood is commonly made 7 in. wide and 4 in. deep, and should, of course, be thoroughly creosoted. One of the objections to concrete beneath the rails is the time required for it to set; this greatly interferes with rapid completion of the work, since it would be its destruction to allow traffic to begin until the cement had hardened. There is, consequently, a great temptation to use very quick-setting cements for this work, whereas the cements that show the greatest durability are slow-setting cements.

The gauge in a tramway of this kind is not so easily defined as on a railway, on account of the wheel flanges running in a groove. To take rolling stock as made for a railway of the same gauge, the distance from the outside edge of one groove to the outside edge of the other should be half an inch less than the railway gauge, and the groove rather larger than it is ordinarily permitted to be made for tramways. The gauge is maintained by tie-bars, placed at intervals of 6 ft. or more between the rails. See the half section in 71.

Rail Joints. The joints of the rails are even more troublesome upon a tramway than on an ordinary railroad, since they are covered up and inaccessible, except at the cost of taking up the roadway. Sometimes boxes are provided alongside to enable them to be got at, but unless the boxes are large enough to enable the whole of the joint to be examined, and the bars to be removed and replaced, they are not of much benefit.

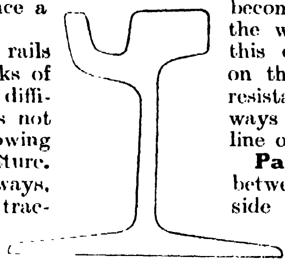
When a joint becomes loose, dirt and grit work in between the parts and prevent any

efficient tightening up, so that the parts must be taken out and cleaned before being tightened.

The rail joints of a tramway may be examined by placing on the top of the rail, over the joint, a straight edge 5 ft. long. If a depression of as much as $\frac{1}{16}$ in. appear at the joint, it must be seen to.

Another system, that does not necessarily exclude the above, is to overhaul thoroughly all joints at regular intervals—say, once a year.

One advantage of having the rails hemmed in on both sides by blocks of wood or granite setts, is that the difficulty of making good joints is not complicated by the necessity of allowing for the expansion due to temperature. Since the track cannot move sideways, the only effect of expansion or contraction is to produce stresses of tension or compression in the rails themselves, which they are well able to sustain.



73. TRAMWAY RAIL

Continuous Rails. The rails may therefore be made continuous by welding each one on to the next, so that there are really no joints at all. The welds may be effected by means of cast-iron, by electricity, or by *thermit*. The first requires a miniature blast furnace to produce the cast iron, the second a formidable electric apparatus, but for the third only a few pounds of mixed ferric oxide and finely-divided aluminium is wanted. This, on ignition, supplies a quantity of superheated molten iron, and by means of this a very intimate union is effected between the two rails. The chief drawback rests in the possibility of failure. Bad workmanship on an ordinary joint may be rectified without much trouble, but if a weld fail, the ends of two rails are ruined. The heat involved in a weld is so great that time must be allowed, before proceeding too far, for cooling to take place, with its accompanying contraction of the rail. This somewhat limits the speed with which a tram-line can be laid with welded joints.

Points and Crossings. The curves and angles being necessarily sharper upon a street railway than upon an ordinary railway, the points and crossings cannot be straight; they must in all cases be specially constructed to the angle and to the degree of curvature to be laid out in the place they are to occupy. This special construction takes time, and all frogs, etc., that must be specially made, should be ordered from the manufacturers as early as possible, since the completion of the work is necessarily delayed until they are delivered and put down.

Whether for facing points or trailing points, a single tongue is sufficient, and most commonly used. Its use obviates the need of a pointsman, except in times of very heavy traffic.

On less frequented roads, the motorman stops just over the point as he comes up to it, and, leaning over the dashboard, can alter its position by means of a hooked end iron hanging there for the purpose. The actual point in the frogs and other parts liable to special wear are usually composed of specially hardened metal, and the groove may here be made more shallow, so that the wheels roll on their flanges while passing the gap, and thus diminish the bump, which cannot be entirely avoided.

Resistance. When the groove of the rail becomes choked with dirt and stones, the wheel flanges grind upon it, and this effect, together with the friction on the sides of the flanges, causes the resistance to traction on such tramways to be double that on an ordinary line of railway.

Paving. The paving of the road between the tram-lines and on each side of the rails, is a matter of great importance to the proper maintenance of the way. Wood paving is often insisted upon, and there is danger that the swelling of the wood between two rails after prolonged rain should destroy the gauge by bending the rails or tilting them. When wood paving is used, it is therefore necessary to have substantial ties, placed closer together than would otherwise be necessary. The wood blocks will then sometimes arch themselves between the rails, causing a hollow beneath, while the swelling lasts. For facility in making repairs, asphalt is to be preferred as a paving material; it is also to be preferred for hygienic reasons, giving less access to unwholesome organisms. But for durability and economy, hard woods give better results than asphalt, and a safer footing for the horse traffic. Granite setts are not tolerated in most towns on account of the noise made by the traffic over them. They form, however, one of the best defences to that most troublesome form of wear which is occasioned by the tendency of the other vehicular traffic to run close to the tram rails.

The tram rails themselves form a track of least resistance, at which the horse traffic seems to aim by getting at least one wheel on a tram rail. Even if this be successful, unless the gauge of the vehicle is the same as that of the tram line, the other wheel will be just off; and usually both wheels are running off and on all the time, causing excessive wear to the road in the neighbourhood of the rails, which is unduly expensive to make good.

Tramway Costs. The cost of laying street railway will be approximately £4,500 to £5,500 per mile of single line. Of this, the rails and fastenings will account for 20 to 22 per cent.; special work in points and crossings, etc., 9 to 10 per cent.; ballast, sand, and materials for concrete, 13 to 15 per cent.; paving materials 29 to 32 per cent.; labour, 15 or 16 per cent., the remainder being miscellaneous.

Continued

TIMBER IN THE SHOP

Sawing and Planing. Varieties and Purposes of Saws and Planes. How to Use and How to Keep them in Good Working Condition

continued from page 3547

By WILLIAM J. HORNER

IN the working of timber in the shop, there is usually some preliminary marking out necessary, and then the first tool used is the saw, including in the term every kind, both machine and hand saws. The saw is by far the most important of all woodworking tools, and its value increases rather than diminishes, notwithstanding the great variety in modern tools.

Workshop Economy. Careful workmen, no matter what class of work they may be doing, always try to avoid waste of material. In cutting up timber some amount of waste is inevitable, but this may be needlessly increased by want of forethought in selecting and marking out. Small pieces, for instance, should not be cut from boards if it be possible to get them economically out of other small pieces—the odds and ends left over from previous sawing. The aim should be to have these scraps left over in as few pieces, and as large as possible, so that they may be utilised for other purposes.

In cases where the shrinkage of timber would be very objectionable, the marking and sawing out of material should be done as long as possible previous to planing or otherwise finishing individual pieces to exact dimensions. If pieces are finished to dimensions immediately after being sawn, and are then allowed to stand while other parts are being got out, or even if they go into place immediately, they will shrink or become distorted to a greater extent than if the freshly-sawn pieces were allowed to stand for a few days to shrink and spring as much as possible before their final reduction to size.

Saws. In well-equipped shops there are always band and circular saws, but we do not propose to discuss them here. They are dealt with in the section on Woodworking Machinery. The various saws for use by hand are always employed, more or less, in those shops where there are machine saws also, because it is often inconvenient or impossible to carry the work in progress to a machine, and in many cases it is not worth while. In the majority of instances, also, the first cut to be made is taken across a board or plank, and as a rule this can be done only with a hand saw, or a two-handled cross-cut for thick planks and squared timbers, or with a circular saw at the end of a swing arm. The last-mentioned type is used only for cross-cutting large pieces of timber, and consequently is kept only in shops where very large amounts of material have to be dealt with, but even then the ordinary hand saw is not dispensed with entirely.

The tenon, dovetail, panel, bow, and pad saws also have their uses even in the best machine-equipped shops, notwithstanding that the larger saws, such as the two-handled cross-cut, the pit saw, the rip, and half-rip, have all been reduced in importance by the increasing use of machine saws, and by the greater variety of sizes in which timber is supplied from the mills, thus lessening the amount of heavy sawing which the consumer has to do. The two-handled cross-cut is still very useful in the same way that the hand saw is, except that it is employed for a heavier class of work; and most carpenters possess a half-rip saw for ripping with the grain. The rip and pit saws may be regarded as almost obsolete.

Saw Teeth. Saws vary in general form, and in the shape and size of their teeth, according to the kind of work for which they are intended. As a general rule, for large work, large types of saws with large teeth are required, and for small work the reverse. The teeth angles vary according to whether the saw is intended for cross-cutting or ripping, or for hard or soft wood. Figs. **77**, **78**, and **79** show the angles of ordinary teeth. Saws for ripping [**78**] have more hook or forward rake than those for cross-cutting. The amount of *set*, or extent to which the teeth are bent slightly to each side alternately, varies, for the same reasons, from nothing to a considerable amount. Saw blades are always made as thin as possible consistent with strength. This is because the less material the saw removes the more easily it does its work.

The Hand Saw. The ordinary hand saw, although it is the largest one in common use, is the most necessary to wood workers. It is intended chiefly for cross-cutting, but is used for ripping also, unless a half-rip be available. In a shop where there is a machine saw of any kind, only small amounts of ripping are ever required by hand. The usual length of the hand saw is 26 in., with five or six teeth to the inch, often slightly diminishing in size and consequently increasing in number towards the point or farther end of the saw. The blade also is generally slightly thinner here than at the handle, where more strength is required, and the back is thinner than the portion where the teeth are, so that the blade will pass through the cut with as little friction as possible. A good saw blade should bend easily, and spring back perfectly straight again. The bending should be uniform, indicating that there are no inequalities in thickness and in temper. No twists or lumps should be visible when the surface of the blade is viewed edgewise. Neither should there be any local slack or strained places in the blade. These, if they are bad, will be visible in the want of truth of the surface, but they may be detected more readily by a peculiar rattling sound which the blade will

emit if shaken. The handle should be securely attached. If there be the slightest looseness between the blade and handle, it will become worse in course of time.

Setting. The *set* of a saw is the amount to which the teeth are bent sideways, as shown in **77** and **86**. The purpose of this is to make them cut a kerf wider than the thickness of the blade, so that the latter will follow easily. The maximum amount of set is required in saws intended for cross-cutting soft wood, especially if the wood be not thoroughly dry, and the minimum for ripping hard dry wood. There are a number of methods of imparting this set to the teeth, and it is necessary to do it periodically, though not every time the saw is sharpened. The simplest method is by means of a hand-set [**80**], with the saw held either in a vice or in the hand. As it is important that the degree of set should be uniform, this method cannot be recommended unless there is also an attachment for stopping the set at a certain point. Another simple way is by means of a hammer on a bevelled or round-edged block [**81** and **83**]. This also requires some amount of skill in order to ensure satisfactory results, though it is the one commonly adopted by professional saw sharpeners. A more exact method is by means of a block and punch [**82**], four different bevels being cut across the block, and the saw set on the one best adapted for it. Another, suitable for small saws, is to punch them on the end of a block of hard wood. There are also a number of useful appliances sold, such as **85**, that ensure precise results. Instead of being set, teeth are sometimes swaged or compressed by a suitable appliance to an increased thickness near their points.

Sharpening. Saws are *sharpened* by filing the teeth with a three-cornered file [**87**]. This has the same section as the tooth space, and thus files the front of one tooth and the back of the preceding one simultaneously. One, two, or three strokes of the file may be necessary to remove sufficient material to restore the keenness to the tooth point, and to make the entire depth of the gulleting of the tooth the same as it was originally. The file is not held at right angles with the blade, but is tilted to produce acute instead of square edges to the teeth. It follows the set, therefore, alternating with each tooth, so that all the teeth that lean to one side have acute points at their outer faces on that side, and all the others alternating have acute points on the other side. This may be seen in the end view [**86**], showing the set. These angles must also be uniform; and to simplify the work as much as possible, all the alternate teeth are done with the file leaning one way, and then the saw is turned round in the vice and the reverse teeth done. This transverse angle is greatest in saws with most set. Where there is no set, the edges are generally filed square.

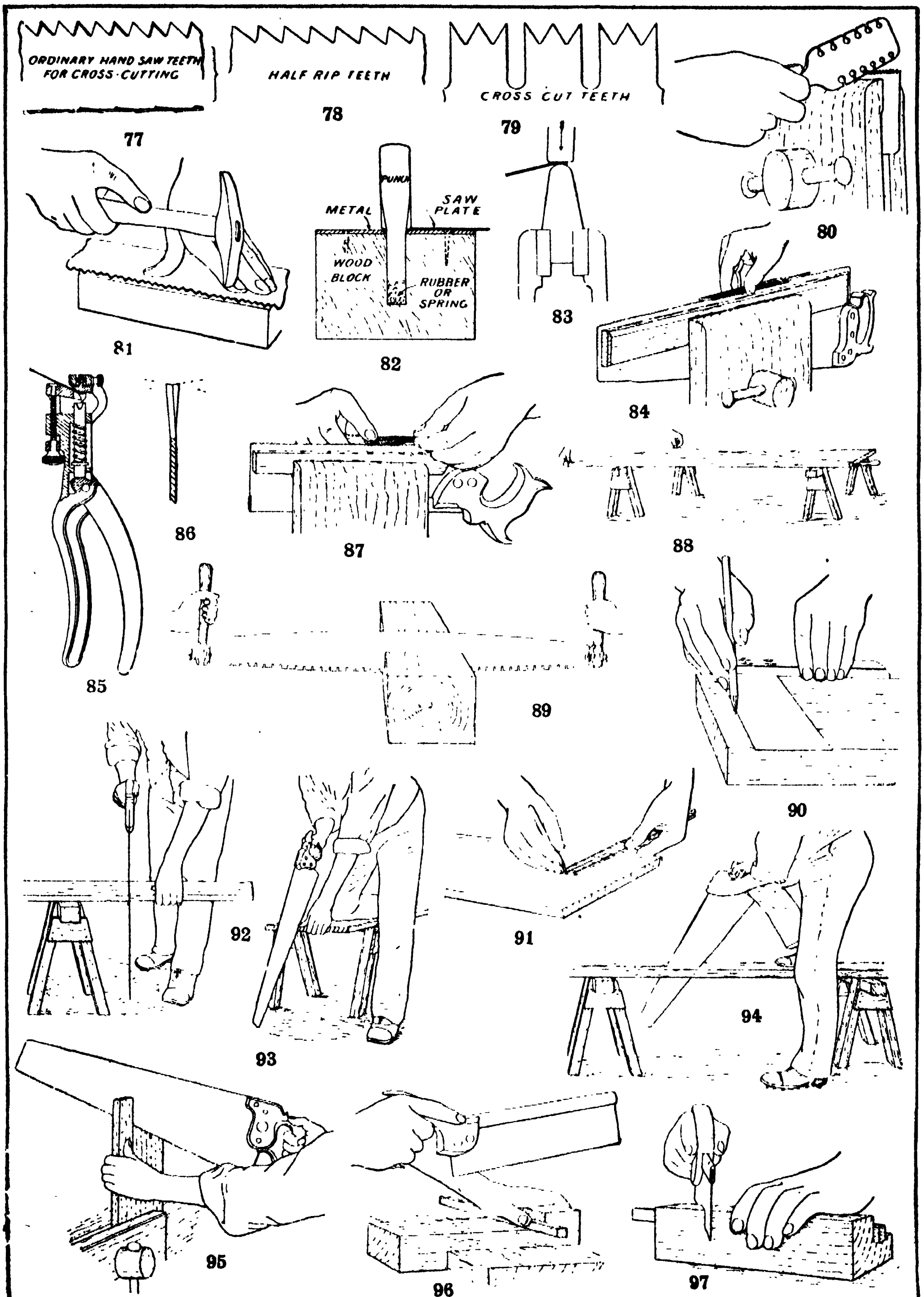
It is necessary also that the points of the teeth should all be level. They are made so by topping them with a flat file [**84**] before sharpening. Sharpening is always done with the saw held teeth upwards in a long-jawed vice, the teeth projecting only slightly above the jaws. Very often a pair of wood jaws, or two strips of wood the full length of the saw, are clamped within any ordinary bench vice, the saw being enclosed between them [**84** and **87**].

Lining Out. Work is marked out by various devices. For cutting down boards, a chalked line is used [**88**], which is a strained cord held by a man and boy at opposite ends, or held at one end by a bradawl and pulled by a man at the other. Then, being strained up vertically at the centre, and allowed to snap back on the stuff, the chalk transferred from the line to the timber leaves a perfectly straight white mark for cutting by. For marking across boards, the try square and lead pencil are used [**90**]. Pencil lines are sometimes marked parallel with an edge by using the rule and forefingers as a gauge [**91**].

Sawing. With the exception of the two-handled cross-cut [**89**], all the saws cut during the forward thrusting stroke, and not when being drawn back. In starting a cut, little or no pressure is applied, but the saw is moved slightly backwards and forwards in very short strokes, guided by the thumb of the left hand [**93**], until the teeth have fairly entered the stuff. The full stroke is not given until the saw is well into its cut, and in no danger of slipping out. Then the left hand may be removed and used to steady the wood [**92**], or when that is not necessary, it may assist the right in working the saw [**94**]. The wood is held in the most convenient position for sawing, and means must be taken to balance or hold each portion so that it will remain in its relative position until the saw is completely through. Otherwise, the fall of one or both parts before the cut is completed will split the remaining portion away. Or if, in sawing across a board, the piece be supported near the ends, and is being sawn in the middle, the severed portion will tend to close and pinch the saw. The "cut" should, if possible, be strained slightly open, so that the saw will work easily, and in working across grain the sawing should finish as lightly as it commences, because even a slight breaking away of the fibres at a corner is often seriously detrimental.

The most convenient position for sawing boards is to lay them on stools or trestles [**92, 93**, and **94**]. This raises them to a convenient height and leaves room below for the saw to work through them. Occasionally, only one saw stool, or a box, or any support about 2 ft. or more in height, is used, the board lying at an angle, with its farther end on the ground; but two supports, at a suitable distance apart, are best. Short pieces of wood are often held in the vice [**95**], but this is suitable only for cutting with the grain, or sawing out sweeps. A great deal of sawing is done on the bench, either against the bench hook [**96**], against the stop, or against dogs driven into the bench, but the tenon or other small saws are mostly used for this work. Fig. **97** shows sawing against a mitre block.

Sawing Straight. Considerable practice is necessary before anyone can saw to a line and cut squarely through the wood, the latter being



SAWS AND THEIR USE

77 to 79. Shapes of saw teeth 80. Setting with a hand set 81. Setting with a hammer 82. A block for setting 83. A block held in a vice 84. *Topping*, or levelling, the teeth points 85. A Morrill saw set 86. End view of a blade, showing set of teeth 87. Sharpening saw teeth with a file 88. Using a chalk line 89. Using a cross-cut 90. Squaring a line across a board 91. Pencilling a line parallel with an edge 92. Cutting across a board 93. Commencing a cut 94. Using both hands 95. Sawing in a vice 96. Sawing against a bench hook 97. Sawing a mitre

more difficult than the former. A straight line often proves more difficult to follow than a curved one, because in the latter case a narrow saw, the course of which can be instantly changed, is used, while if a hand saw inclines away from the line it can only be brought back gradually. A saw may be following a line, and yet be considerably to one side of it on the other side of the material—that is, the saw is not plumb. This is an error that a beginner is certain to make, and should pay especial attention to when sawing thick stuff. The tendency is generally to incline the handle end of the saw toward the side on which the person is standing. By giving it what seems a contrary slope, it will then generally be found to cut squarely, and after a little practice the operator's eye will tell him whether it is cutting square, or inclined to either side. Until the eye is sufficiently trained to do this, tests may be made, if necessary, with a square during the progress of a cut.

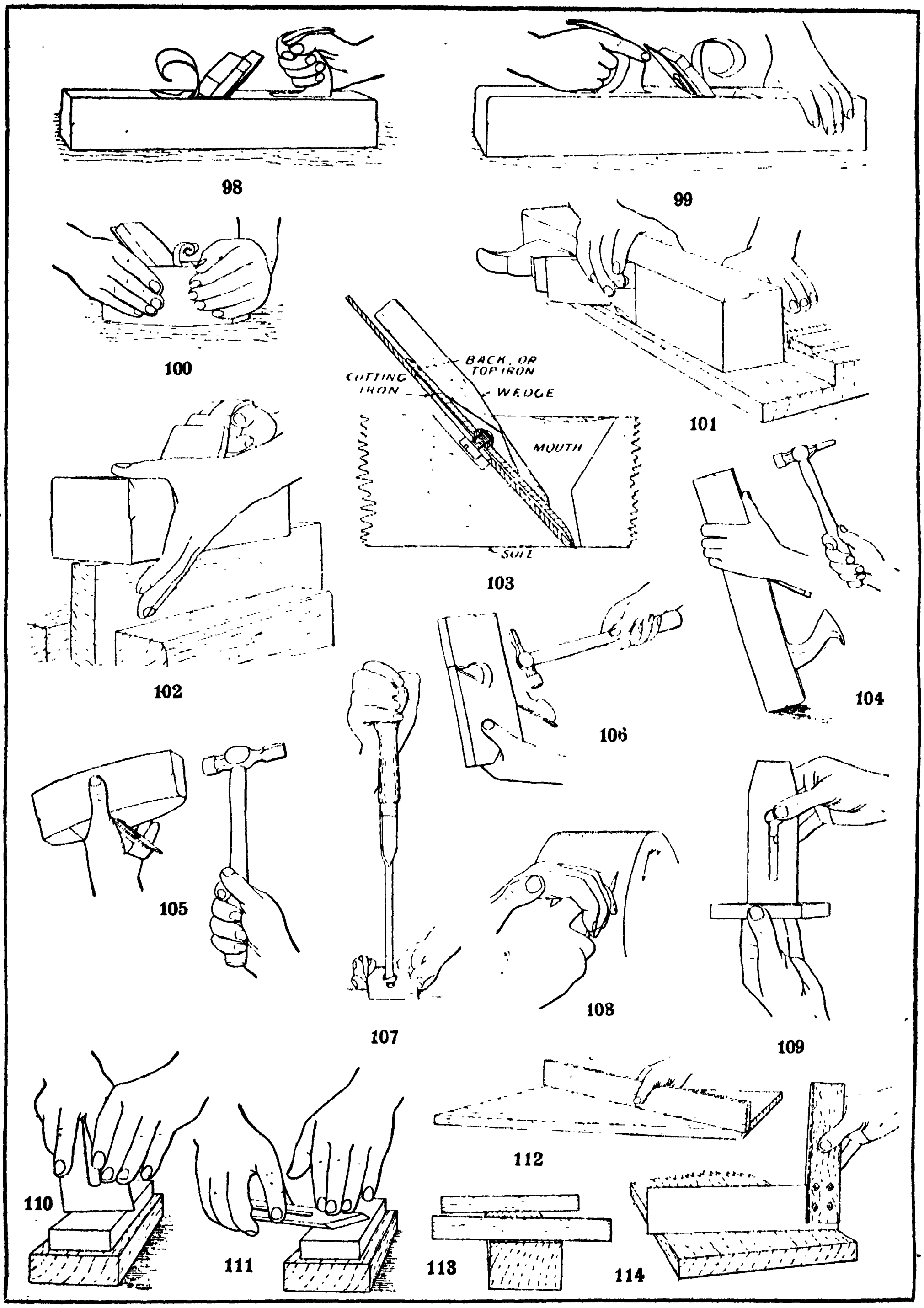
Straightening the Saw. If a saw is in the habit of running persistently to one side of a line it will generally be found to be due to a defect in the saw itself; either that the blade is twisted slightly, or the teeth have more set on one side than on the other. An untrue saw blade, or one in which the tension is unequal, is corrected by hammer blows; but if it be hammered elsewhere than in just the right places it may be made worse and bruised with hammer marks as well. Twists and lumps may be removed by laying the blade on a flat block of metal or hard wood, and hammering them down. Slack and tight places in the blade require skilful treatment with a hammer. The principle is that tight or strained places can be slackened by hammering, which spreads the metal in those parts and at the same time makes adjoining slack places uniform in tension with those which were tight. Places that are slack will, if the saw be held horizontally, fall, or can be easily pressed into a concavity, while the tight surrounding part remains level.

Planes. The three principal planes used by woodworkers are the *trying*, *jack*, and *smoothing* planes. These are always kept on the vice end of the bench, with their fore parts resting on a strip of wood which prevents the cutting edges from becoming damaged by contact with the bench. These planes and their uses have already been described in the chapter on tools [page 3385]. They are made both in wood and metal, the latter being preferable, but as they are more expensive they have not yet become so popular as wooden planes.

If the surface of a piece of timber has to be made merely smooth, regardless of accuracy, the smoothing plane is used, sometimes preceded by the jack plane when the surface is very rough or irregular. If it has to be planed truly—that is, with perfectly flat faces, square with each other—one face is first roughed down with the jack plane and then finished with the trying plane. Next, an edge is planed straight and square with the true or *trying* face. Then the gauge is brought into use, and the opposite edge gauged and planed parallel with the first. The thickness is now marked with a gauge, and the second face reduced almost to the gauged lines with the jack plane, and finished with the trying plane. The ends are then planed square with faces and edges. In very long pieces of wood, especially in planing long edges, a plane a few inches longer than the ordinary trying plane, called a *jointer*, is sometimes used. Two jack planes are also often employed, one for roughing down, and one set more finely for preparing for the trying plane.

The Art of Planing. The shavings are removed by grasping the handle with the right hand [98 and 99], and pushing the plane over the surface in as long strokes as the arm can conveniently make. At the end of the stroke the plane is raised sufficiently to finish the shaving, and the plane is then drawn back and another cut parallel with the first is taken, or a step forward is made and a continuous shaving taken. In planing a long edge for a glue joint, or in other important work with a trying plane, the tool is never raised, but a continuous shaving is cut along the entire length, the plane being stopped at the end of one stroke and moved carefully on again as the operator walks by the side of the board. That, of course, is in the finishing cuts. At the commencement there is always more to be planed from some parts than others. In using the jack plane either one or both hands are used according to circumstances [98]. In using the trying plane both hands are employed on the tool, the right grasping and pushing the handle, the left bearing on the fore part [99]. The smoothing plane is always grasped with both hands [100]. Sometimes the trying plane is used on a shooting board [101]. The wood is then held down by the left hand while the plane is slid on its side by the right. This is for planing edges, the alternative being to screw the wood in the vice [102].

End Grain. End grain is more troublesome to plane than longitudinal work, and it is always best, therefore, in squaring ends to saw almost to the line, or to pare with a chisel so that the plane may be used only for finishing, and not for removing a quantity of material as it often is when working with the grain. Care must be taken also not to let the plane split the edge of the wood away at the end of a cut, on end grain. This may be prevented by bevelling the corner off with a chisel, so that the plane ceases to cut before the extreme weak edge is reached. With a little care the plane may then be used on the end grain without fear of breaking the farther edge away, and if it be necessary to plane the bevel out to leave a sharp corner, the plane must be turned and used in the opposite direction, so that the cutting always commences at the edge and stops before the cutter reaches the opposite edge. For squaring ends and cutting end grain, a mechanical trimmer is always used in preference to a plane, if possible. At the ends of planks, where the wood is of



PLANES AND THEIR USE

98. Using a jack plane **99.** Using a trying plane **100.** Using a smoothing plane **101.** Using a trying plane on a shooting board **102.** Planing an edge with wood in vice **103.** Section through a plane **104.** Loosening wedge and iron **105.** Loosening a smoothing plane wedge and iron **106.** Knocking back a rebate plane wedge **107.** Turning the screw of a double iron **108.** Grinding an iron **109.** Testing the curvature of the cutting edge **110.** Sharpening **111.** Removing the burr, or wire edge **112.** Testing a surface with a straightedge **113.** Testing with winding strips **114.** Testing planed surface with the edge of a square

cracked and full of dirt, an inch or so is always sawn off and thrown away if the end has to be planed. Finishing to length is done on the same principle as the reduction in other directions, one end being first planed square with sides and edges, and then the required length marked, and a line squared across, and the material beyond this line removed.

Plane Irons. The irons or cutters of these three planes are usually what are known as *double irons*, one, the *iron* proper, being the cutter; and the other, called the *back iron*, being screwed to it in order to stiffen it and lessen the risk of its tearing up the grain. In jack planes, for coarse work, a single iron only is often employed, and in planes other than the three types we have been considering, a single iron is the rule. The back iron is screwed to the other about $\frac{1}{16}$ in. or $\frac{1}{32}$ in. back from the cutting edge and the double iron is then inserted and wedged in the same way as a single one would be [**103**]. For adjustment, the irons, after they are wedged, are tapped forward, or on either side, by a hammer, if the edge be out of square with the sole, or, if it project too much, the plane is given a blow on the fore part. This causes both iron and wedge to move back and consequently become loosened slightly, so that a tap on the wedge is then necessary to tighten it again. Striking the plane on the fore part is also the method adopted for getting the iron out to sharpen it [**104**]. The smoothing plane, being very short, can have its wedge loosened more readily by a blow on the back [**105**]. The beginner who is not skilful in using a hammer should be as careful as possible not to bruise the plane in doing this. In the trying and jack planes a good plan is to bore a hole about $\frac{7}{8}$ in. diameter and about $1\frac{1}{2}$ in. from the end of the planes, and, say, $1\frac{1}{2}$ in. deep, and to insert a hardwood plug with a rounding top standing about $\frac{3}{8}$ in. above the surface, and use this plug to hammer on. The wedges of moulding and rebate planes are generally made of a shape that can be knocked back directly [**106**]. The cutters of iron planes of the large class are adjusted, and tightened and released, by screws, cams, or levers, so that hammers are not used on them.

Sharpening Plane Irons. Plane irons are *ground* and *sharpened* in the same way as chisels, and to the same angles, but one important thing in the grinding and sharpening of the irons of the jack and smoothing planes which can be disregarded in chisels, is to impart a slight curve to the edge, so that when projecting below the sole of the plane they will cut a shaving slightly thicker in the middle than at the sides. At the extreme sides, in fact, the shaving must taper to nothing, and the corners of the iron must not touch the timber, otherwise they would leave unsightly ridges. In the trying plane iron, however, which is required for accurate work, the cutting edge must be as straight as possible consistent with the above-mentioned requirement. In the smoothing plane slightly more rounding is permissible, and in the jack plane, especially if used for very coarse work, a good deal of convexity, often $\frac{3}{32}$ in. or more, is given to the edge, because thick shavings can then be cut without difficulty. In a jack plane used for ordinary work the middle part of the cutting edge should project about $\frac{1}{16}$ in. below the sole when the corners are still within. Fig. **107** shows how the parts of a double iron are screwed and unscrewed when taken out fo sharpening. Fig. **108** shows how an iron is held during grinding. In grinding and sharpening the amount of curve present is tested by restin the edge vertically on a flat piece of wood and holding it up to the light to see exactly to wha extent the corners are ground back [**109**]. A plan iron curved the opposite way, or hollow, will no work at all, as the shavings will corrugate an choke the plane mouth.

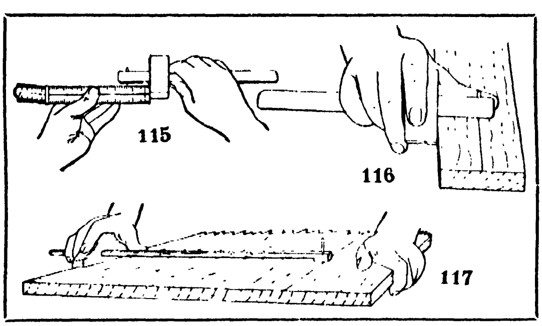
Regarding the angles for grinding and sharpen ing, planes for soft wood may have more acut cutting edges than those for hard wood. I all cases the angle should be as acute as wi stand usage for a reasonable time withou resharpening. The angles range from abou 5 to 25 degrees with the sole of the plane, th iron itself being set in the plane at an angle about 50 degrees. The ground or bevelled pa of the cutter in this class of planes, and wi only one or two unimportant exceptions in planes, is downward [**103**]. Fig. **110** shows ho an iron should be held during sharpening on oilstone, and **111** shows how the burr should rubbed from the face.

Choking of Shavings. This, as alrea mentioned, may be caused by an irregula ground iron in which the corners project t much. It never occurs in coarse jack plar where the cutting edge is very rounding. may also be caused by a very obtusely-grou iron, or by an untrue sole, or, in a few instanc in new planes, as a result of trying to plan shaving thicker than will pass through the mou easily. If it be due to the last-mentioned cau the defect soon cures itself, because as the mou wears back it widens, and the iron also is gen ally thicker at the end than further back, a so becomes thinner at the mouth as it wea The width of the mouth can easily be increa with a chisel or file, but it should be touch only at the narrowest part. For doing f work a narrow mouth is necessary, and wh in a wood plane the mouth has greatly increa in width through the wearing back of the s workmen find it advisable to reduce it ag by inserting a block of hard wood in the sol front of the iron

Truing a Plane. The soles of all pla should be perfectly true. This is especi important in the case of the trying pla which has to plane other surfaces true and a large surface of its own which will get ou truth more readily than a small one. I necessary therefore occasionally to *shoot* or p it true. This is always done with the iron wedge in place, but the cutting edge, of cou kept within the mouth, so that the body of plane is in its normal state. The simp and most expeditious way is to pass it a finely-set jointing or planing machine if

be available, but if not, it is screwed in the vice, sole upwards, and thin shavings are taken off in the ordinary way with another trying plane. The surface has to be carefully tested with a straightedge and winding strips to ascertain whence to remove shavings. Soles are hardened and lubricated by the application of linseed or other oil which is allowed to soak into the wood. New planes are better, also, if they are protected from dirt by two or three coats of shellac varnish.

Testing Planed Surfaces. An experienced man sees a great deal with his eye that beginners have to find out by testing with instruments, and so the former will make a surface approximately true before he begins to test its truth. The degree of accuracy, however, must always be verified by instruments in all cases where accuracy is of importance. The chief instruments used are *straightedges*, *winding strips* and *squares* [**112-114**]. Straightedges are long strips of wood with edges perfectly straight, so that they can be used for testing other pieces. The piece of wood being operated on may be tested with them lengthwise, transversely, and across corners [112]. When the surface is nearly true, the straightedge is generally chalked, and the chalked edge is rubbed across the surface at various points, leaving marks of chalk on the high places that require planing down. For testing a board transversely, the edge of a steel bladed square is more convenient than a wood straightedge, because, being thin, the light can be seen under it where there are hollow places in the surface [**114**]. For testing long pieces lengthwise the eye alone is often sufficient, especially if the piece be so thin that it bends easily; but if not, a straightedge as long as the piece must be used. To test whether there is any twist or wind present on the surface, *winding strips* are employed [**113**], or if the piece of wood is of considerable width, a straightedge may be tried across the surface diagonally from corner to corner [**112**].



THE USE OF THE MARKING GAUGE
115. Setting a gauge. **116.** Gauging a line. **117.** Gauging a line with a panel gauge

Testing with Winding Strips. In testing with these, the eye is really the judge, but the strips exaggerate the amount of twist so much that the eye requires no training to see it. Winding strips are simply two parallel straightedges which are placed on edge across the piece of wood to be tested, as shown in **113**. The strips, being considerably longer than the width of the wood upon which they are placed, follow the inclination of the surface at each end and extend beyond the edges, so that when a glance of the eye is cast along from one end over the top edges of the strips, it is easy to see whether they are parallel, or whether one dips one way and the other the opposite way. They are then taken off and shavings are planed off the high corners of the surface until the strips show that the twist in the surface has been removed.

Planing True. In all pieces of wood that have to be accurately planed one of the surfaces must first be made true by tests of this kind. Nearly all boards are more or less curved transversely, and it is best when they have to be planed to a definite thickness to true the hollow side first, because if the edges are not planed under thickness it will then be certain that the middle part will hold up; and, because, if there is much to be planed off, it is best to take most off the rounding side to cause it to shrink more there and counteract the tendency to curve. When one surface has been planed true the square is used on an edge to get it exactly at right angles with the true surface, and a straightedge may be used to find when the edge is straight. Then gauges [**115**, **116**, and **117**] are used to mark lines parallel with these planed surfaces, and straightedge tests are no longer necessary except transversely on the opposite surface, the plane working to the gauged lines. In all work where planing and cutting with chisels are concerned, lines are, as a rule, gauged or scribed and not pencilled, because a pencil line is not accurate enough. Pencil lines are preferred for sawing by because they can be more easily seen from a distance and because sawing either presupposes rough work, or work that must have further lines marked afterwards for finishing to. In many cases finishing lines are scribed, and the saw kept well to one side of them.

Even if dimensions are unimportant, true surfaces and accurate angles are always essential in fitting work together. They make the chief difference between good work and bad, and are the main difficulty which the beginner must master.

Continued

Continued from page 3530

THE GUITAR AND ZITHER

How to Hold the Instruments. Tuning. Fingering. Positions. Scales. How the Finer Effects are Obtained

By ALGERNON ROSE

THE guitar has six strings, the top three being of gut, and the lower three of silk overspun with silver wire. According to their thickness so is the quality of the sound affected. The smallest gauge makes the tone sharp and brilliant, and the largest full and round. Medium sizes are best.

The pupil should be seated when playing. Place the right foot on a fairly high footstool. Rest the hollow, or curve, on the treble side of the instrument against the right knee. The bass side of the guitar should incline backward so as to be supported by the chest. Ladies rest the guitar in the lap. Spaniards play as often from the left knee as the right. When the instrument is played standing, to facilitate change of position in fingering, extend a ribbon from the peg provided for that purpose to the head of the guitar and pass this over the right shoulder. Place the right arm round the big end of the instrument, so as to hold it without the assistance of the left hand [1].

Dispose the right fingers perpendicularly over the strings. The first finger should be over the third string, the second finger over the second, and the third over the first. Elevate and curve the wrist. Keep the thumb away from the other fingers. They will thus be more independent when striking a chord. The usual place for the right hand is midway between the bridge and the soundhole. When playing very softly, strike the strings immediately over the hole. The thumb negotiates the three silver strings, or bass notes, E, A, D. Occasionally it is used for the third and second strings, G, B. To produce the best tone with the thumb, twang from left to right, and stop the next string. Avoid "wagging" the hand up and down.

1. POSITION OF PLAYER

Place the left thumb under the neck of the guitar between the first and second frets. This forms a fulcrum for the other fingers. Bring these round gracefully on to the fingerboard, right and left, above the thumb. Stop the notes not with the flat but with the tips of the fingers, firmly, close to the frets. Keep each finger down until the full value of a note has been sounded.

It is important for the student to study the course on Harmony [page 363], so as to understand how chords and arpeggios, appropriate to the guitar, should be built up, for all charm in playing vanishes if a wrong harmony is employed.

Tuning. The accordatura, or tuning, simple. Tune the thickest string in unis with E (one ledger line below bass clef) the piano. Having done this, place the seco finger on the fifth fret of the string. Sound t note with the right hand and tune the ne silver string, A, in unison with it. Then st with the same finger the fifth fret of the seco string, and tune the third to the note give This will be D. Put down the finger on the sa fret of the newly-tuned string. The ne sounded will be G. Tune its neighbour unison with it. Remember at this point put the second finger on the fourth (not t fifth) fret of the fourth string. The result w be B, to which note tune the fifth string. Th put the second finger on the fifth fret of B. T note sounded will be E. Tu the sixth string in unison with If the right hand now strikes t strings one after another, th will sound in succession E, A, G, B, and E, the first four no having fifths between them, t fourth and fifth strings soundi an interval of a fourth, and t fifth and sixth strings anoth interval of a fifth. This irreg larity in the intervals between t strings enables the guitarist to g certain effects usually impossi on the violin.

But noted guitarists have n been satisfied with this inequal in the intervals. To get furth effects, they have deliberate made the six strings disagree s more, in the same way th Paganini mistuned his violin order to obtain unusual resu and puzzle his brother fiddle A *scordatura*, as it is called, skilfully employ by a good guitarist enables him to get new effec The beginner, however, will carefully tune in t orthodox fashion.

The Positions. Put the first finger on t first fret of the D string, and the second, thi and fourth fingers on the second, third, a fourth frets of the G, B, and D strings. The ha is now in the first position. It is in the seco position, or the third, fourth, fifth, and so on the twelfth, when the first finger is over t corresponding fret. In guitar music, 1, 2, 3 4 dots to the left of a note, or immediately un it, sometimes guide the player to the positi for his left hand. An O over a note signifies open string, or one which requires no stopp by any finger.

For the chromatic scale, begin on the lowest string, E. Keep the fingers off it. Strike with the right thumb. Put the first left finger down firmly on the first fret. Strike the string. This gives F, a semitone above. Put the second finger on the second fret. The note produced will be F♯. Put the third finger on the third fret. The sound is G. Now place the little finger as firmly as possible on the fourth fret. This will give G♯. Do the same thing again with the fifth string. The notes A, A♯, B, C, and C♯ will result. Continue on the fourth string. D, D♯, E, F, and F♯ will be obtained. Take the third string in the same way. Note that the little finger is not used with the third string. The sounds will be G, G♯, A, and A♯. Proceed to the second string. Again use all the four fingers. The effect will be B, C, C♯, D, and D♯. Lastly, go without interruption to the first string. Use all four fingers of the left hand. The sounds played will be E, F, F♯, G, and G♯.

Meanwhile, the left hand fingers used should be the first and second alternately—not the thumb. The left thumb is never employed to stop any of the strings. It is kept underneath the neck to enable the four fingers above to articulate the notes firmly and gracefully.

It is not advisable to make a pivot of the little finger of the right hand, as beginners are apt to do, by resting it on the soundboard. Keep the little finger up ; this allows the right hand to become light and lissom.

Having ascended the scale, go down the gamut in the same way. The pupil will now have executed the chromatic scale of 2½ octaves, and have learnt the fingering of each half note.

The Natural Scale. By omitting all the sharps, but keeping to the same fingering, proceed to practise the natural scale. When this becomes easy, vary it by using the first instead of the second finger, and the second instead of the third, so as to get more tone, wherever (as on the fifth, fourth, and third strings) the first finger would otherwise play a sharp in the chromatic scale. The hand is thus shifted temporarily to the second position.

One of the greatest difficulties in guitar playing is usually regarded as the ability to finger all the scales and chords correctly in the different positions. Professor Prout, in Vol. I. of his "Orchestra," emphasises this. But the great guitarist Duverhay points out in his "Method" that if the student studies well the natural scale of C major, and learns the fingering carefully, he can make the same fingering serve for all the other scales and chords by transposition. We give below the manner of fingering C. [Ex. 1.]

Remember always in scale playing, whether chromatic or diatonic, that whereas four fingers may be necessary for all the strings except the third, three suffice for the G, or middle string, because it is tuned a fourth below B, whilst all the others are in intervals of fifths.

The Shifts. If the first finger is used for the second fret, the hand is what is called in the second position, or shift. It is in the third, fourth, and so on, up to the fifth position, as the first finger stops the apposite fret.

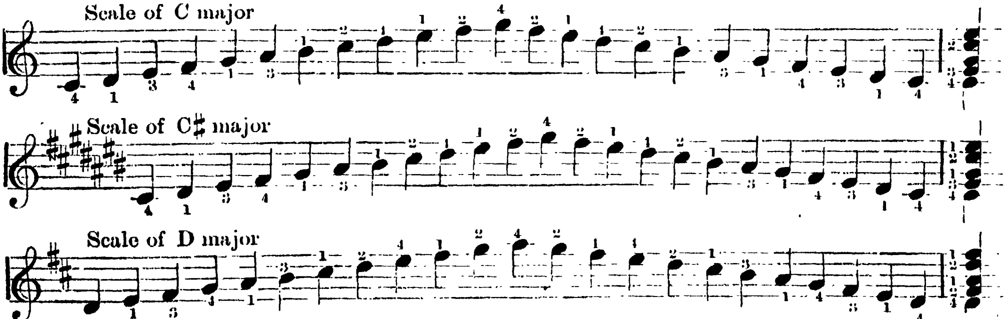
When the student has made acquaintance with these different positions, he will proceed to playing what is known as *barré*. Place the first finger of the left hand across the neck of the guitar, so as to stop more strings than one at a time. Strike the strings. It will be observed that those which are stopped are raised equally in pitch. By this simple device many passages in guitar music, which would be otherwise difficult to execute, are made easy.

The effect known as Grand Barré is so-called when the first finger is laid across the fingerboard and the other three disengaged fingers are used to stop the strings as required, five or six strings being sounded as an arpeggio or chord. Little Barré is obtained by laying the first finger across merely a few strings, so as to stop a chord from the first to the fourth string. This plan of simplifying the playing is indicated as "2 P.B.," "3 P.B.," and so on.

Capotasto. An easy method of raising the pitch of the guitar permanently at any given fret is to screw over the strings on to the fingerboard an artificial headstop. By this contrivance the pitch of all the strings is raised, and the clear effect of fresh open strings retained. This temporary nut is called the "*Capotasto*" or "Capodastro," its use being denoted by the words "con capotasto sulla 3 P," 4 P, or whatever position is required [2].

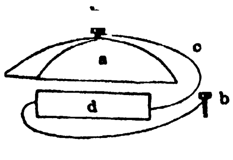
The advantage of this will be evident when the player is asked to accompany a song in a higher key than that given in the music. With the capotasto he can play with ordinary fingering and

Ex. 1. **MAJOR SCALES**



[And so on through all the Major Scales, the first finger of the left hand shifting up one fret at a time]

use the open strings, although the key has been changed. For duet playing the capotasto enables two guitars, one with and one without the artificial headstop, to play concerted music which usually would be rendered by a mandoline and guitar. Allusion to the capotasto has been made to emphasise the desirability, when playing barré, of the learner putting his first finger down with weight, so as to make it do temporarily what the capotasto does—*i.e.*, cause the tones of the strings to resemble as closely as possible those of open notes produced by the stress of a natural top-nut.



2 THE CAPOTASTO
a. Body *b.* Peg *c.* Peg-string *d.* Leather

When a note, or group of notes, ascending, is *glissé*, pluck the first note with the right hand. The fingers of the left hand slide firmly to the succeeding note, and cause the sound to ascend as the vibration continues. When this "son porté," or "carried sound," is descending, after striking the first note, slide the finger in the opposite direction, taking care always to change the fingering correctly as each successive fret is reached.

In the slur the first note is struck by the right hand. The fingers of the left hand must stop those notes which succeed as strongly as possible, and "pull" them pizzicato fashion.

Harmonics. Harmonics are made by placing one of the fingers of the left hand very lightly over the fret, and playing with the thumb or the first finger of the right hand. The best natural harmonics are those of the third, fourth, fifth, seventh, ninth, and twelfth frets. Although the left hand stops the string gently, the right hand strikes forcibly and close to the bridge. Harmonics "à double doigter," or produced with two fingers, are made by stopping a note first in the usual way. At the same time, the right thumb touches the middle of the string lightly, whilst the first right finger strikes the string underneath. This produces a sound an octave higher than the natural tone of the string stopped.

A characteristic guitar effect is the *Twirl.* In this the thumb forms the centre of an imaginary circle, and the tips of the other fingers twirl round it so that the right hand makes a convolution by sweeping all the strings in succession above the rim of the rosette, or sound-hole. If done properly in chord playing, the trick is delightful.

Another subtle conceit, or piquant effect in chord playing, *Les Ongles*, is made by running the finger nails of the right hand lightly across the strings from right to left.

The *Tambour*, or drum effect, is executed by raising the right hand a span over the sound-board, and dropping the side of the thumb with a free action from the wrist across the strings close to the bridge.

Again, for the effect known as *Corni*, strike energetically with the thumb and first finger, but with a closer action quite near the bridge. The effect is supposed to resemble the sounds of horns. "Corni" is also played by using the tips of the nails close to the bridge, or a single horn is imitated by all the notes of a phrase being sounded by the nail of the first finger on one of the silver strings.

Son Étouffé is a sudden damping, or stifling, of chords when they are struck. It is done by the fingers being replaced immediately on the strings after striking them, or the sudden staccato is obtained by employing the whole of the right hand to damp the sound. This effect is marked ⊕.

Vibrato is not possible on the open strings. It is done by making each of the fingers of the left hand, after stopping a note, tremble firmly and evenly on the string. Practise making this motion slowly at first. A player capable of making a good vibrato, especially with his weaker fingers, produces a better quality of tone than an amateur less accomplished. Although, theoretically, a throbbing sound is opposed to the production of a pure and equal tone, it has a peculiar charm on the guitar, and good players who are able to make the notes pulsate can render entire passages unusually expressive.

The Tremolo. The tremolo is a rapid repetition of one or more notes struck alternately by the thumb and first finger of the right hand, the second and first finger, the thumb and second, the thumb, second, and first, or by varying the order of manipulation in other ways. Practise the different methods of fingering for the *Tremolo* systematically. The exercise adds to the suppleness of the right hand. It is as useful as is the practice of the vibrato for each of the left fingers.

Guitar concluded

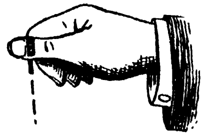
Ex. 2. FANDANGO FOR GUITAR

THE ZITHER

For zither notation two staves are employed. One is for the melody and the other for the accompaniment. Both are usually in the treble clef. There are two methods of tuning—the first is that adopted in Vienna, and the second that in Germany. We will confine our attention to the now general German method.

Tuning. The first string on the fingerboard nearest the player is of steel. It is tuned to A, second space treble clef, as is also the second string, the object being to get reiterated effects from two strings in unison. Brass wire is used for the third string. This is tuned to D below first line. The fourth string is of steel overspun with silver wire. It is tuned to G below second ledger line. The fifth is of brass overspun with copper, tuned to C below fourth ledger line.

player. In playing, both thumbs are used, the only fingers unemployed being the fourth on both hands. Place the thumb and three fingers of the left hand on the frets of the fingerboard. In sounding a note be careful to incline the left fingers to the right inner side of each fret, otherwise the tone will not be good. While the left fingers form the notes, the melody strings are plucked by the right thumb. Over this is worn a clip of German silver ending in a prong, called a zither ring. The upper portion of this prong forms a semicircular band of the thickness of an ordinary ring. The clip goes over the base of the thumb-nail, the prong being underneath, and protruding to



3. ZITHER RING

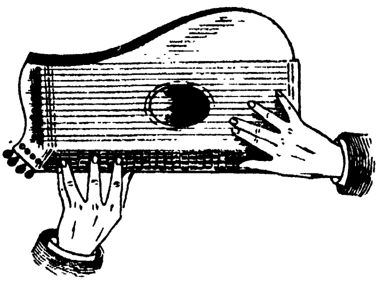
Ex. 3. MINUET MOZART

the left [3]. When at rest, the position of the right thumb is for the plectrum to be over the middle melody string D. The first right finger should rest on the second wire-covered accompaniment string, C; place the second finger on the third wire A, the third finger on the third bass string F, and allow the fourth finger to remain free. It should follow the movement of the third, and not be rested on the tailboard—a bad habit contracted by careless players. Keep the joints of the fingers straight. It is the sides of the fingers and not the nails that have to come in contact with the strings. Therefore do not appear to attempt to pick up the strings by curving the right fingers. On the contrary, endeavour to press them [4]. Thus, rest the third finger heavily on the F string. Now, when the finger is removed,

Next come the accompaniment strings. Of these there are 13. The first, second, fourth, sixth, seventh, ninth, eleventh, and twelfth are of catgut; the third, fifth, eighth, tenth, and thirteenth being of silk covered with wire. The contrasting substances of the strings are employed not merely as a help to the player, but have a peculiar effect on the individuality of the zither tone. Beyond the 13 accompanying strings are the 13 bass strings. These are all of silk, covered with wire and of a thicker gauge, so as to give the deeper sounds. The diagram given shows the complete scale.

Position of the Player. Place the zither on a table of bare wood. If the table rests firmly on the ground it magnifies the sound of the instrument. The zither should be put obliquely with the fingerboard towards the

the act of its slipping off will cause the string to vibrate. The third finger should fall against the next string on the left, B♭, and impel it almost against its neighbour. But no sound other than the F will be heard. Finger pressure must be regulated according to the thickness of the string. For instance, it will not be necessary to use the same degree of force if the second right finger is pressed stiffly against the third accompanying wire, A, because that wire is of quicker utterance than the F.



4. FINGER POSITION

Having made this motion, try to play two strings at once with one finger. Rest the first finger firmly on the second wire, or fifth accompaniment string from the left C. Now pass it quickly from the C to the F, or the catgut string on its left, so as to sound both simultaneously. In doing so, the finger motion must finish on the third string, B♭, the digit resting firmly against it. A little thought will cause the pupil to realise that the arrangement of the accompanying strings admits of common chords and their inversions being played by two instead of three fingers. The pressure of one finger when passing to an adjacent string should be so rapid that the sounds of the two are merged. This would not be possible were the accompanying strings not tuned in fourths and fifths as they are.

In using the zither ring, play gently at first. Fulness of tone must be acquired evenly and gradually. It is easier to develop a *forte* by the slow and sure method than to begin carelessly and learn afterwards to play with delicacy.

Fingering. Fingering in zither music is indicated by a + for the thumb, 1 for the first finger, 2 and 3 for the second and third, and an 0 for an open string.

Before the fingers get accustomed to their duties and gradually harden, excessive practice will do more harm than good. Progress will be more rapid if the pupil practises for half an hour on the first day, and adds an extra quarter of an hour the second day, and so on up to a maximum of two hours, rather than if he tinkles upon the instrument during the whole of his evening leisure for the first two or three nights, and then lay the instrument aside in disgust.

Positions. There are six positions on the fingerboard in general use, besides three others more rarely employed.

For the first position, place the third finger of the right hand on the first or second fret, the second finger on the third or fourth fret, the first finger on the fifth or sixth fret, and the thumb on the seventh or eighth fret.

For the second position the third finger now comes on the third or fourth fret, the second finger on the fifth or sixth fret, the first finger on the seventh or eighth fret, and the thumb on the ninth or tenth fret.

For the third position, the third finger is placed on the fifth or sixth fret, the second finger on the seventh or eighth fret, the first finger on the ninth or tenth, and the thumb on the eleventh or twelfth.

Continue in the same way, moving every finger up one or two frets each time, so as to become accustomed to the fourth, fifth, and sixth positions. The player should make out a diagram, numbering and lettering the notes of each position. Get to know them automatically, so that any note indicated in the music may be produced with certainty. The less the fingers are shifted, the smoother will be the effect.

Double Notes. In playing double notes, hold the left hand obliquely towards the right. In the higher part of the scale, thirds are played by putting the left thumb on the first A string, and the second finger on the second A string. Practise sliding the fingers; do not lift them when passing from one fret to another. In playing sixths, the two A strings are not used together; the lower note required will be found on the string next to that which produces the higher note. Octaves, like thirds, are always played with the thumb and second finger. The ease with which a glissando, or sliding over intervening frets between two notes, is produced is one of the greatest charms of the zither. This effect, next to the *portamento* in singing, is indicated by a slur in the music. In making the slide, first put down the thumb deliberately. Then turn it over, so that the nail may touch the string. Do not hurry. After the ring on the right thumb has caused the string to vibrate, the sound will ascend or descend naturally according to the movement of the left finger, or fingers. Two notes linked together in the music by a slur must be played on the same string. Be careful not to remove the thumb after a glissando until the note has sounded its full value, or the charm will be destroyed.

When an open string is struck with the right thumb, and the interval to be slurred up is a big one, do not slide the whole length. It is better to make the glide only in the higher section of an interval in ascending or the lower section in descending. Take care to touch the string very lightly at first, and increase the pressure gradually. If the interval is a long one, the thumb ring must be used a second time to mark its conclusion.

The Shake. The shake is not so easy to execute on the zither as on the piano. When made closely and rapidly, its charm rewards the player for the time spent in practising it. Place the second finger on the note indicated in the music over which is printed the sign *tr*∿∿. Then put down the thumb on the next fret, or the next but one, as may be necessary for the trill. Press the tip of the first finger against the thumb to

steady the latter. Let the thumb and second finger rise and fall alternately. Practise the shake slowly at first, evenly, and accelerate the speed gradually.

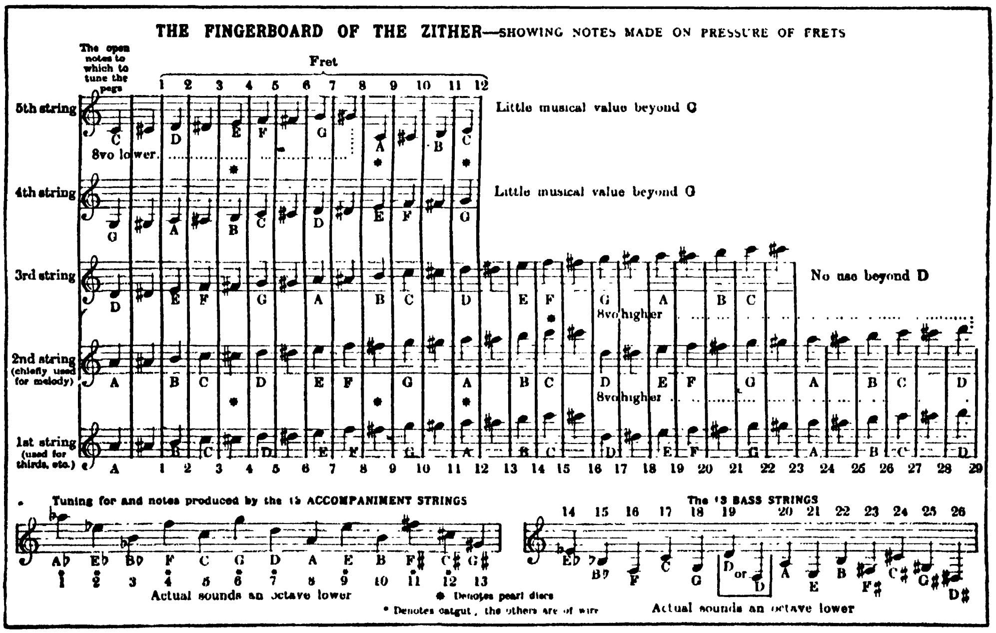
Vibrato. There are so many charming effects to be obtained out of this instrument that its admirers have not yet decided which is the most beautiful. But many of them maintain that the zenith of the zither's sublimity is only reached through the magnetic *vibrato* tone of which it is capable. Place one of the left fingers on the requisite note. Move the finger from left to right, backwards and forwards, from the tip. The motion must not be made from right to left. Avoid jerking the strings. The player who once contracts the bad habit of making the strings shake, will find it difficult later to cure himself of that defect. What is wanted is a sense of rapid but gentle pulsation—not a series of spasmodic jerks. The quicker the vibrato, if done in a smooth manner, the better will it sound. By its means the tone of any of the melody strings may be prolonged, the continuous trembling caused by the motion of the metal wire impinging on the metal frets seeming to reinforce the sound.

The sound of the strings is diminished when the word "*dolce*," or *pp*, is indicated in the music, by advancing the right hand over the circular hole in the sounding board. What is known as the *harp effect* is thereby obtained.

Bell Notes. What are known as *bell notes* are of two kinds—natural and artificial. To produce the former, place the thumb lightly on the string above the required fret, exactly over it instead of a little to the right, as for notes which have to be stopped firmly. Sound the note with the right thumb by the "ring." Bell notes are also called *flageolet tones*. They are harmonics, and sound an octave higher than written. Natural bell notes are produced by touching lightly the open strings at different points. The artificial harmonics are made by stopping certain frets and then touching very lightly a higher fret with a disengaged finger.

If the pupil has memorised the names of each of the accompaniment and bass strings so as to associate them instantly with the notes that represent them, he will be ready to practise what is known as a *running accompaniment*. In this, each note is articulated separately, beginning on the lowest string. Major chords or arpeggios present little difficulty [Ex. 3]. Minor chords are easy to produce if the necessary third is supplied by the melody strings. The right hand then plays as if for the major chord, without using the second finger. Keep the right hand quiescent when playing full chords. Press slightly with the fingers. Withdraw them delicately. In staccato chords the fingers must be taken off instantly after making the sounds. Replace them immediately on the strings to damp the vibration.

Zither concluded



THE FINGERBOARD OF THE ZITHER—SHOWING NOTES MADE ON PRESSURE OF FRETS

Continued from page 3566

FROM MINE TO MARKET

Surface Works. Winding Plant. Mine Ventilation and Lighting. Mine Gases. Screening, Washing and Crushing. Ore Roasting

Mine Tubs, or Corves. The system of haulage most suitable to the conditions of working having been selected, it remains to describe the vehicles employed to convey the materials from what is known as the *working face* to the bottom of the shaft. For this purpose stout iron carriages, or *tubs*, are employed, although wooden ones are still used in some of the Cornish mines and in several collieries. Numerous devices have been suggested for attaching the tubs to the rope, where rope haulage is employed. These usually take the form of a friction clutch, although in such cases the wear of the rope is apt to be considerable. The chief trouble arises, however, from the fact that the roads are apt to be dusty, and great difficulty is therefore experienced in keeping the axles and bearings free from dust and properly lubricated.

Winding. Methods of winding have necessarily to be modified by the various factors to be considered, such as depth of shaft, nature of materials, etc. In coal-mining practice the tubs are run into the cages previously described, and drawn to the surface by a rope which winds round the drum of the winding engine. A typical shaft, with cages, and the road leading from the working to the bottom is illustrated in 99.

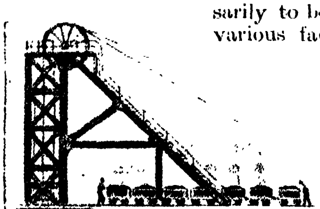
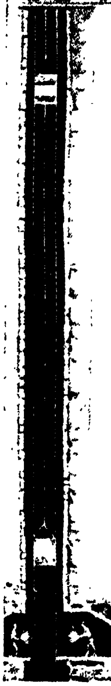
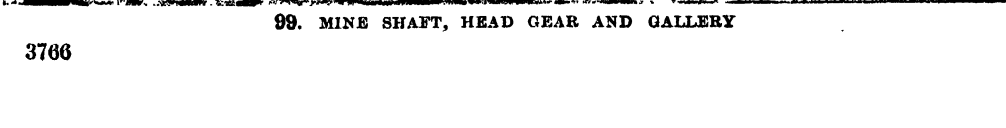
Some of the methods of attaching the rope to the cage are highly ingenious and worthy of being described. The reader will readily appreciate the necessity for the *capping*, as it is termed, being performed with the utmost care, as, when the miners are being raised or lowered on their way from or to their work, their lives often depend almost entirely upon the security of the capping. When wire ropes are used, the method is to unfray the strands and to bend them back upon themselves. This gives the end of the rope a bulging, conical shape, and it can then be slipped into a conical sleeve, or socket. The greater the stress on the rope, the more firmly is the end drawn into the socket, and this method of attachment has been found, generally speaking, very effective.

Just as the strength of a chain depends upon the strength of its weakest link, so, theoretically, the strength of a wire rope depends upon the strength of its weakest strand. In practice, however, the margin of strength—that is, the reserve resistance to breaking stresses over that which in practice the rope has habitually to endure—is such that it is permissible to have a few strands broken, provided the number does not exceed the percentage allowable for the particular type of rope used. The best ropes are of crucible steel wire, wound round a core of best manilla hemp, the winding being done in such a manner that the more tightly the rope is drawn, the more firmly do the strands of which it is composed interlock and become compacted. These ropes require liberal lubrication with carefully selected oils, free from acids which would cause corrosion and speedily ruin the rope. Ropes of this description have been used for many years past at Prizbram, where one of the shafts has reached the stupendous depth of 3,642 ft. These ropes have a tensile strength of 114 to 120 tons per square inch.

Safety Catches for Cages. When the cage has been raised to the pit-mouth it must be secured, so that all risk of its falling back in the shaft may be avoided. This is effected at many collieries by an automatic device called a *kep*, which practically consists of an iron or steel step, pivoted or hinged in such a manner that, although it can be lifted up by the passage of the rising cage, it cannot yield in the opposite direction unless deliberately liberated by a hand lever. Once the cage has passed it on the upward journey, it forms, therefore, a secure ledge, or step, upon which the cage can be brought to rest for the purpose of unloading.

Needless to say that the number of devices which have been put forward for the above purpose is considerable, but most of them differ only in some slight detail from the foregoing, the principle of which is almost universally adopted. In "diggings" of a primitive nature, when both the men and the materials are raised and lowered by a bucket worked by a windlass, the simple expedient of placing a plank across the mouth of the shaft, once the bucket swings clear, answers the purpose admirably.

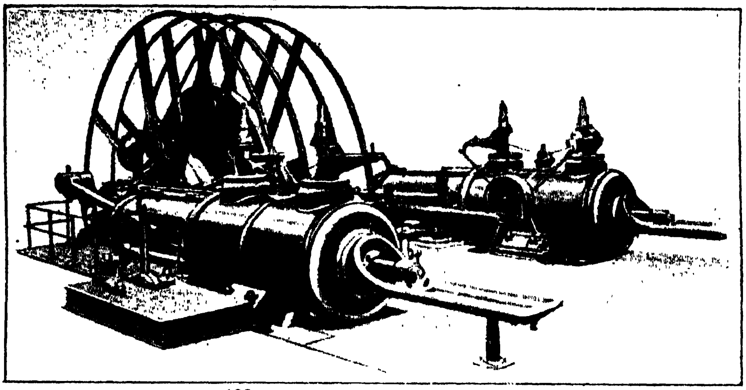
Human ingenuity has also been abundantly displayed in appliances for preventing "overwinding"—an accident of a very serious nature,

99. MINE SHAFT, HEAD GEAR AND GALLERY

as, in addition to the loss of life it may entail, the whole of the pit-frame may be almost irreparably damaged.

Winding Engines. A brief description of a large steam-engine recently exhibited at the International Exhibition at Liége will suffice to acquaint the reader with the size and power of the engines employed at the present time. The engine in question is shown in **100**. It has a drum 24 ft. in diameter, and is capable of raising nearly four tons of coal a distance of 1,300 yd. at a speed of 15 yd. to 20 yd. per second. With central condensation, and working under favourable circumstances, this engine will give results which, it is claimed, are not surpassed by those of any electrical installation extant. Of late years winding engines driven electrically have been adopted at most of the large collieries abroad, and are rapidly making progress in this country.



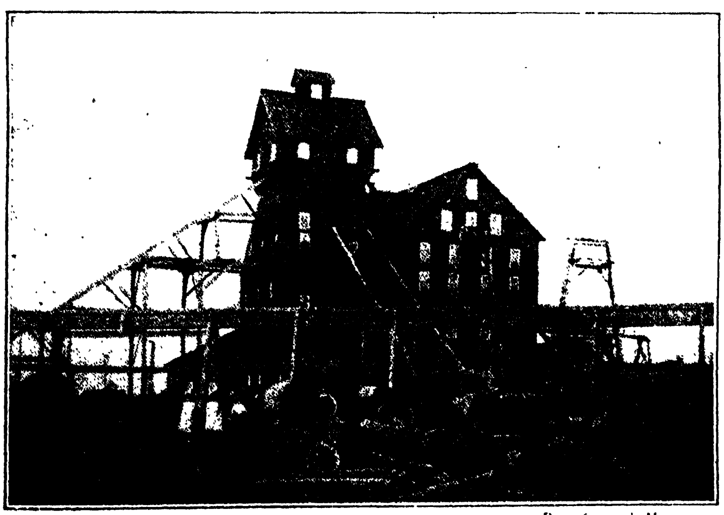
100. STEAM WINDING ENGINE

A point of great importance in winding is the position of the winding engine in relation to the pit-head gear. If too close, the inclination of the ropes may be such that the pull on the frame is too great, and it may be drawn backwards towards the engine. On the other hand, if the engine be too far away, the power is not applied to the best advantage, and serious waste ensues. The best authorities claim that the distance of the drum from the centre of the shaft should be from one, to one and a half times the height of the pit-head frame.

Pit-head Gear. Over the shaft is erected the pit head gear and frame, which in its essentials practically amounts to a tripod, supporting at its apex the pulley over which the winding rope passes. Actually, the pit-head is a much more complicated device, and serves not only to support the pulley, but also to house tipples, chutes, and, at times, crushing plant to deal with the minerals raised. In **101** is shown the shaft rock house at the celebrated Tamarack copper-mine at Calumet, Michigan, U.S.A.

The cars have a capacity of about two and a half tons, and the rock is dumped into skips and raised to the surface, where there is a combined head-frame and crusher building in which the rock is crushed to a size of five or six inches. Fig. **102** shows a typical pit-head frame at a large colliery, where the coal is raised and subsequently washed, screened, sorted, and run into waggons, which pass beneath the chutes with which it is provided.

Need for Ventilation. Proper ventilation is a matter of extreme importance in underground workings, particularly in coal-mines, where the atmosphere is liable to become dangerously contaminated by noxious gases issuing from the coal-face and from blowers—that is, accumulations of fire-damp, under pressure.



From Cassier's Magazine

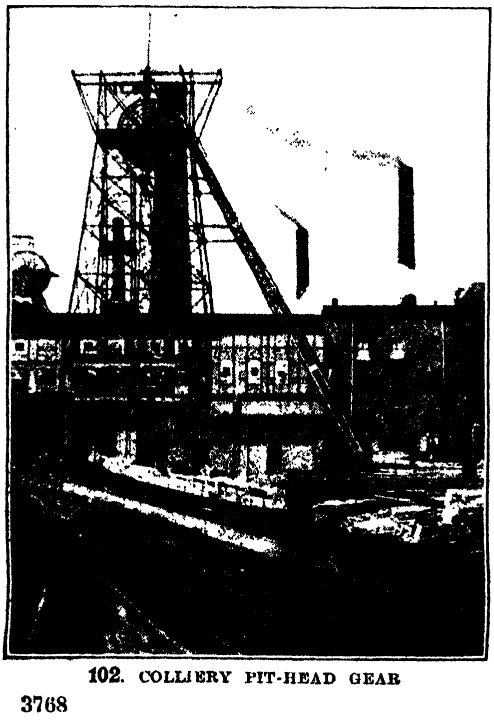
101. SHAFT ROCK HOUSE AT THE TAMARACK MINE, CALUMET, MICHIGAN

Gases in Mines. The principal gases found in mines are shown in the table on the next page, which gives their chemical formulæ, popular names, and chief properties.

Black damp, or stythe, which is not enumerated in the table, as it is not a pure gas, but a mixture of gases, was formerly believed to consist of carbon dioxide. Recent researches have, however, shown it to contain 85 to 88 per cent. of nitrogen. It resembles carbon dioxide in its

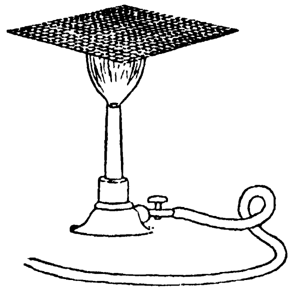
properties, and supports neither life nor combustion. Some of these gases are heavy and tend to collect in the lower workings of the mines. Others are lighter than air and collect near the roof. As these are generally explosive gases, their danger is increased, as they are more readily diffused. All the foregoing gases occur, more or less, in collieries, but they are also met with in metal mines and in non-metallic mines other than coal mines. Thus, carbon dioxide is common in lead mines in Spain, France, and the United States. On the other hand, the gas sulphuretted hydrogen usually occurs in minute quantities only, in coal mines, where it is formed by the decomposition of pyrites in coal. In sulphur mines, on the other hand, it is frequently present in large quantities, and has been the cause of serious accidents in Sicily, and during the sinking of a shaft through the rock-salt beds of Strassfurt no less than fifteen fatal accidents occurred where persons were asphyxiated by sudden outbursts of the gas.

Chemical Name and Formula.	Popular Name.	Remarks.
Carbon monoxide, CO.	Carbonic oxide, or white damp.	Very poisonous: explosive.
Carbon dioxide, CO_2.	Carbonic acid, or after damp, choke damp.	Poisonous, but non-explosive.
Methane, CH_4.	Marsh gas, carburetted hydrogen, or fire damp.	Highly inflammable.
Sulphuretted hydrogen, H_2S.	——	Highly inflammable and poisonous.
Nitrogen, N.	——	Inert.



102. COLLIERY PIT-HEAD GEAR

Dangerous Gases. Marsh gas and carbonic oxide are, however, the gases chiefly responsible for the disastrous explosions which occur from time to time, mostly in collieries. At the same time, the deaths which occur are usually due less to the explosions themselves than to the deadly *after damp* or *black damp* gases which are formed as the result of the explosion, and cause death by asphyxiation. Marsh gas has, however, been put to useful purposes before now, and, at the Eleonora pit, at Dombrau, in Austria, a large blower of the gas has been tapped and the gas employed to heat two steam boilers, with an annual saving of 600 tons of coal.



103. BUNSEN AND GAUZE, SHOWING PRINCIPLE OF DAVY SAFETY LAMP

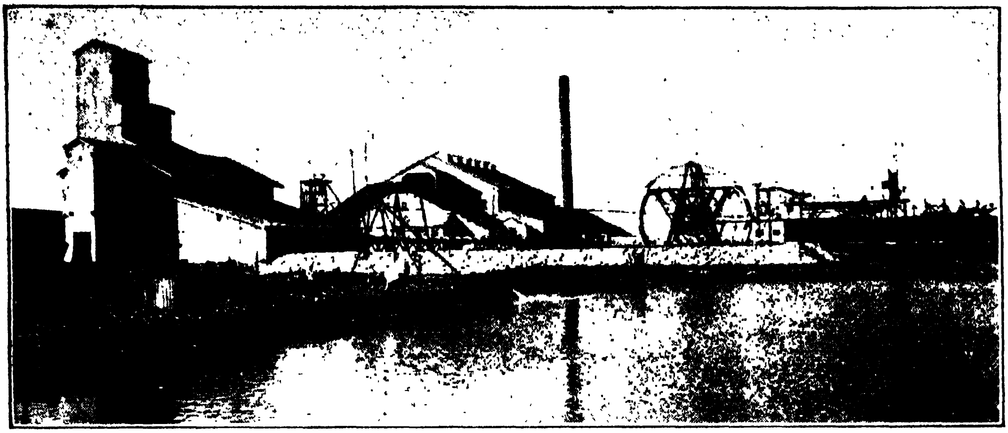
While many mines are commendably free from gases, their presence in others is a standing menace to the miner. At the same time, it has been found that mine gases are not, by any means, the sole cause of explosions. The large amounts of coal dust present in the air of collieries also constitute a grave danger, and many explosions have been traced to this source.

In many collieries, water is sprinkled on the coal after it has been loaded into the tubs and the ways are carefully watered to help to allay the dust. But even this precaution may, in turn, constitute a fresh source of danger, as the warmth of the workings, combined with the moisture, is believed to create a highly favourable *nidus* for the propagation of the deadly *ankylostoma*, or miner's worm, the cause of a disease which has wrought much havoc in collieries in France, Germany and Belgium, but which, happily, has made very little progress in this country.

Ventilation in Mines and Collieries. The need of efficient ventilation will be obvious when it is remembered that, in addition to the necessity which exists for removing the dangerous gases naturally present in collieries and metal mines, the atmosphere is rendered foul by the fumes given off by blasting operations and "shot firing," and by the emanations from men and animals working in a confined space for long hours.

In quarries and opencast workings ventilation is, obviously, easily effected, but it is otherwise with workings situated at great depths from the surface.

Ventilation is usually carried out by one of the three following methods: natural ventilation, furnace ventilation, and fan ventilation. Natural ventilation depends upon the presence of two shafts at least, of different depths, and



104. SURFACE WORKS, FERREIRA DEEP MINE, TRANSVAAL

containing, therefore, columns of air of different weights and pressures. Whenever these conditions are satisfied, the heavier column overbalances the lighter column and a system of air circulation is established. Natural ventilation is, however, subject to some uncertainty in operation, and to the great disadvantage that circumstances may, at times, lead to a total reversal of the direction of circulation, an occurrence which may be fraught with serious consequences. In practice, it is rarely depended upon alone, but is supplemented by a system of furnace ventilation, by which the air in what is called the *upcast* shaft is heated, and thereby rendered permanently lighter, thus ensuring a constant draught in the same direction. This system has, however, been almost entirely superseded by fan ventilation.

Ventilation by Fans. Ventilation by fans may be either by exhaustion or by compression—that is, the fan may be used to withdraw the foul air, or to drive in a supply of fresh air. In practice, fans are usually placed at the top of the up-cast shaft and used to exhaust the air by suction. These fans work on what is known as the centrifugal principle, and as they differ but little in essentials from those used to secure ventilation in large buildings, it will not be needful to do more than to point out that, naturally, they are much larger and more powerful. The chief types used are the "Guibal," "Waddle," "Schiele," "Cappell," "Walker," and "Rateau" fans. The speed at which such fans are run varies from 40 revolutions per minute to 500. They are, at the present day, frequently driven by electricity, and their diameter often exceeds 30 ft.

Lighting. The method of lighting mine workings is closely associated with the occurrence of fiery gases in mines, as, upon their absence depends the possibility of working with naked lights, while their presence necessitates the use of lamps specially designed to prevent the ignition of the explosive gases. Thus, in many parts of the world, and at many of the iron ore mines in this country, candles are used. They are stuck into a piece of clay which, by its plasticity, can very readily be put down anywhere convenient, adapting itself to the circumstances in a way which no more rigid form of holder could possibly do. At other mines oil lamps are freely used. For the most part, however, safety lamps have to be employed.

Theory of Safety Lamps. Before an explosive gas can be ignited it, or some part of it, must be raised to the requisite temperature, as otherwise the chemical forces upon which ignition depends do not come into play. It was found by Sir Humphry Davy that, if a piece of wire gauze be placed across a flame, the unconsumed gas issuing through the gauze cannot be ignited by the flame beneath, but requires an extraneous source of heat to ignite it. The illustration given [103] will make this clear. What really happens is that the strands of wire in the wire gauze are such excellent heat conductors that they carry off the heat of the flame too rapidly for it to be imparted to the gas on the other side to raise it to a temperature sufficient to ignite it. The Davy safety lamp, the prototype of numerous modifications since invented, depends upon this fact for its safety.

Preparation for the Market. While the operation of mining ends with the delivery of the minerals at the pit or shaft head, it is but seldom that such minerals can be directly employed in industry. In practice they have usually to be subjected to a series of operations which, as they are usually carried out at a mine or colliery from which the material has been won, may legitimately be regarded as the final stages of mining.

The chief reason for treating the minerals in the immediate vicinity of their source of extraction is to avoid the expense which would be entailed in transporting the dirt and dross with which they are almost inevitably associated —in other words, to obviate freight and carriage charges upon unremunerative tonnage. Even coal, which of all minerals is usually in the condition most suitable for immediate consumption, generally requires some degree of preparation before consignment to its destination.

105. HEAP ROASTING OF COPPER ORE *From Cassier's Magazine*

Screening Coal. With coal, the value of the marketable product depends largely upon size. On reaching the pit mouth it is therefore subjected to a series of operations which include screening, picking, sorting, and washing.

Screening is carried out by tipping the coal either on to inclined screens, set at an angle of about 30°, or into revolving or shaking screens. The size of mesh employed depends upon a variety of circumstances — for instance, the hardness of the coal, its ultimate uses, etc. At most large collieries *jigging* or shaking screens are employed, the movement imparted to such screens being comparatively gentle and regular so as to avoid breaking the coal too much in the process.

Coal Washing. Small coal intermixed with a large proportion of dirt is usually *washed*. In this process advantage is taken of the difference in density between the coal and its associated impurities. The principle employed is agitation with water, whereby the coal, being lighter, is carried away, while the heavier impurities collect at the bottom of the appliances used. There are a large number of coal washers on the market, the best known being the Murton, and the Wood and Burnett washers, which have movable troughs; the Luhrig, Coppee and Robinson washers, which depend upon the action of ascending currents of water; the Elliot washer, which is provided with movable scrapers operating in a fixed trough, and the Baum washer, which is practically a large vat into the water of which compressed air is admitted, causing considerable agitation of the water and effecting a very complete degree of separation by this means.

Coal washing effects a considerable reduction in the ash of the coal treated, and also serves to remove a proportion of the associated sulphur compounds which are a source of grave inconvenience in most of the subsequent uses to which the coal may be applied.

Gold Washing. It will have been seen that this process of washing tends to *concentrate* the material—that is, the finished product is richer in the required mineral than it was before. This principle is applied to an even greater extent in gold mining, particularly in alluvial workings where the prospector's pan, described on page 2380, is further developed into the *batea*, a conical vessel in which the heavier gold collects at the bottom, while the dirt flows out with the water at the top. At some gold mines, notably in Australia, the contents of a large pit are agitated with water by means of a series of revolving blades. This principle is also employed at the Kimberley diamond mines to separate the mud and clay from the gravel with which the diamonds are associated.

Crushing. While it is usually desired to keep coal in large lumps, it is sometimes crushed preparatory to coking in the coke ovens. The crushing of minerals finds its most interesting exemplification, however, at gold mines, where the gold is derived from quartz, which requires to be reduced to a fine powder preparatory to *leaching*—that is, treating with chemical solutions which dissolve out the gold, leaving the quartz behind.

On the Rand, the ore mined is a hard, splintery rock known as *banket*, or *almond rock*, a siliceous quartz conglomerate, consisting of bluish-grey quartz pebbles embedded in a quartzose matrix. This quartz has to be treated in stamp batteries, which consist of hammers shod with specially hard steel, such as chrome steel, or manganese steel. These hammers work vertically by means of a tappet, or collar, fixed near the top end of the rod to which the shoe is attached. This tappet is raised by a revolving lifter, furnished with a cam which, on rotating, engages with the lower surface of the tappet, raises it a few inches, and ultimately clears it, allowing it to fall. A number of these vertical hammers disposed side by side, having their tappets actuated by cams projecting from a common shaft which revolves continuously, constitute a stamp battery. The weight of each stamp—rod, head and shoe, and tappet—averages about half a ton, and the number of falls per minute, regulated by the hardness of the quartz, averages from 60 to 100 per minute.

Stamping is carried on either wet or dry. In the latter case the fine dust is liable to be carried about in all directions, and to become deposited on the working portions of the stamps with serious results, although the leaching is more rapidly effected with dry stamped ore. The usual practice in South Africa, New Zealand,

America and Australia, is wet crushing. As its name implies, the ore is mixed with water in the mortar box, into which the stamp falls.

Leaching. Leaching is a process whereby the materials from which it is desired to extract some valuable constituent are treated, in a vat, with some liquid which dissolves the required constituent. Thus, in alkali manufacture, the salt "cake" is leached with water, which dissolves the soda salts, leaving the associated silicious matters, fuel, etc, untouched. In gold mining the fine ore from the stamps, which is known as *tailings*, is leached with a solution of cyanide of potassium, which dissolves the particles of gold—and silver, when this metal is present—and leaves the quartz slime behind after filtering. Fig. 104 shows the surface workings of the plant at Ferreira Deep, with the large tailings wheel on the right.

The dissolved gold is subsequently precipitated on zinc plates, or zinc turnings, zinc having a chemical affinity which causes it to withdraw gold from solution and to take its place. The zinc remaining is ultimately driven off by heat, leaving the gold, in the form of crude bullion, behind.

Roasting Ores ; Calcination. Some minerals, when delivered at the surface, are associated with substances which can be driven off by heat. In other cases, the application of heat may cause certain chemical reactions to occur which have the effect of rendering the mineral more readily reducible in the subsequent smelting operations to which it is usually subjected.

The ore may be roasted in heaps, or calcined in kilns. Sometimes the heat is derived from combustible materials associated with the ore as extracted, the combustion of which produces sufficient heat to effect the necessary changes in the mass. With other ores, fuel must be added before combustion can be effected. The best example of ores of the first class is afforded by blackband ironstone, which contains enough carbonaceous material to burn without any added material. In Scotland and in North Staffordshire, where this ore occurs, huge heaps may be seen roasting in the vicinity of the mines. Such ores may lose as much as 50 per cent. of their original weight, and the iron they contain will be in a more fully oxidised condition. Where the addition of fuel is necessary, the preparation of the ores is more economically carried out in kilns. In the Cleveland district, the kiln adopted is that of Gjers, the capacity being from 400 to 700 tons at a time, and even more. The waste heat from the blast furnaces is also employed for the purpose of calcining the ores. The ores of many other metals also require roasting preparatory to their use, while in the case of non-metallic minerals numerous examples might be adduced. Thus limestone, or calcium carbonate, is roasted in kilns to drive off the carbon dioxide, for the production of lime, and in cement manufacture. Fig. 105 shows the roasting of copper ores in heaps at Jerome, Arizona.

Weathering. In a number of instances materials require to be exposed to the action of atmospheric agents before they are fit for use. Into the process of weathering several factors enter. Thus, the mineral heaps become permeated with moisture in wet weather, and in the succeeding cold seasons the moisture freezes, and by its expansion induces disintegration of the masses.

The diamond-bearing rocks of the Kimberley district are weathered on a large scale, the rock being spread over areas extending thousands of acres. From time to time the masses are ploughed up and fresh portions exposed to the atmosphere, the weathering rendering the subsequent operations for the recovery of the diamonds much easier and cheaper. Clay also requires careful weathering and ripening, its physical properties being greatly improved, and its plasticity increased. It may incidentally be mentioned that the existence of clay itself depends upon the weathering, during long ages, of granite. The silicates of alumina, which enter into the composition of one of the chief constituents of granite, become separated from the quartz and mica with which they are associated, and being lighter, are deposited by the action of water in beds. The kaolin of Devonshire, from which the best descriptions of china and porcelain are made, has had its source in the cycle of operations included under the term weathering.

GEOGRAPHICAL DISTRIBUTION OF MINERALS

The following notes as to the distribution of the chief ores and minerals, arranged under the headings of the countries in which they occur, may prove of interest. It must be borne in mind, however, that the *venue* is frequently changed, and that the country which at one period is "booming" as, say, a gold country, may at almost any period be displaced by a "rush" to some other district from which prospectors may bring the news of important finds.

Great Britain and Ireland. Our own country owes its predominant commercial prosperity as much to its mineral wealth as to its geographical situation. Celebrated in the early dawn of its history as the source of tin ores, its coal, iron, copper, lead, zinc and salt mines have also contributed to its industrial development in later days. The Welsh steam coal is unexcelled for marine purposes. Unfortunately the iron ore mines upon which the prosperity of this country is largely dependent are approaching exhaustion, and the supplies for the ironworks have to be drawn from abroad, notably from Spain and from Sweden, supplemented by ores from the European mainland, from Greece, and even from Russia. Gold is found in North Wales, but in commercially insignificant quantities.

Other European Countries. France, Germany and Russia possess much mineral wealth, coal and iron predominating. Southern Russia and the hinterland between Europe and Asia is rich in petroleum, Baku being the centre of the oil industry. Sodium and potassium salts are found in Germany and Poland, while Austria-Hungary produces quicksilver, which is also found in Spain. Iron ore

is found in Sweden, where it is smelted with charcoal, producing iron of great purity and excellence. Manganese ores are found in Russia, Greece and Turkey, while copper is mined in Spain and Portugal, and traces of ancient workings for the extraction of copper ores are found in Greece. Gold is found in Italy, the chief mineral wealth of which is, however, sulphur.

Asia. The mineral wealth of Asia is not fully known. Gold is found in Hindostan and elsewhere, while platinum is found in Siberia. Persia possesses coal and petroleum. China is a very rich country, and contains ores of nearly all the commercially valuable metals and minerals. Japan is rich in coal and iron. Diamonds, sapphires and rubies are found in Hindostan and in Upper Burmah. Petroleum is also found in Burmah, and in many of the larger islands of the Eastern Archipelago.

Africa. The gold mines of the Rand are justly celebrated; while the Niger States possess valuable deposits of alluvial gold which have not, as yet, been fully developed. Namaqualand is rich in copper ores, and Natal has abundant supplies of coal, a mineral in which the Transvaal is somewhat deficient. Diamonds are found at Kimberley and elsewhere. Algeria possesses mines of lead, zinc, antimony and copper.

America. Canada possesses an abundance of valuable minerals, including gold at Klondyke and in Nova Scotia and Columbia, silver, in the Lake Superior district, iron ores in various localities, coal, petroleum, and lastly, but not least, nickel, which is found at Sudbury, in Ontaria. The mineral wealth of the United States is enormous. It is the chief iron ore producing country in the world, and its output of coal, petroleum and natural gas is likewise on a gigantic scale. The United States also produces a quantity of copper, lead and quicksilver, while gold is mined in Colorado, California, Nevada, Utah, Montana and Arizona. Silver is found in Colorado, and several of the other Western States, and copper abounds in the Lake Superior district. In South America the silver mines of Potosi are celebrated, while the nitrate beds of Chili are the most extensive in the world. Gold and diamonds are found in Brazil, and emeralds in Peru.

Australia and Oceania. Australia and Tasmania are rich in tin ores, while gold is found scattered throughout Australia, and in New Zealand. Coal is found in New South Wales. In Oceania the island of New Caledonia is justly celebrated for its mineral wealth, being rich in nickel, molybdenum, and chrome ores.

Ore Handling. Only a passing mention can be made of the marvellous advances which have taken place in the methods of transporting minerals. The most striking instances are the aerial ropeways by means of which enormous tonnages are cheaply and expeditiously conveyed from place to place, and the wonderful ore handling appliances in the Lake Superior district in America. There the ore is handled by gigantic machines, which feed it into the ore steamers which ply between the mines and the chief ore docks situated on the lakes. The capacity of these steamers is very great, and the limit would not, even yet, appear to have been reached, notwithstanding the fact that the Elbert H. Gary, a steamer belonging to the famous Steel Corporation, has recently broken all records by conveying a cargo of 12,328 tons of ore from Escanaba to South Chicago. For unloading these cargoes, Hulett automatic machines are installed, and one of these, at Lorrain, Ohio, recently achieved the wonderful task of unloading 681 tons in an hour. The speed and economy of these machines may be gauged by the fact that the cost of unloading has been reduced to 1 cent. (½d.) per ton. Indeed, the records of the Old World are fast being broken by those of the New World, and the student of mining fixes his eyes on the shores from which the Atlantic separates, in name only, the Mother Country, and views with admiration and surprise the striking progress which the adoption of scientific methods has enabled to be made in the Greater Britain beyond the seas, whose sons are the inheritors of the glorious mining traditions of the old country in that New Land whose resources so vastly surpass those of our own.

Bibliography. Students who wish to pursue the study of mining into greater detail than this course has provided will find no lack of reliable textbooks on the subject. Messrs. Charles Griffin & Co. publish several good handbooks, among which we may mention "Prospecting for Minerals," by S. Herbert Cox, (5s.); "Ore and Stone Mining," by Sir C. le Neve Foster (34s.); "Elements of Mining and Quarrying," by the same author (7s. 6d.); "Coal Mining," by Herbert William Hughes (24s.); "Mine Surveying," by Bennett H. Brough (7s. 6d.); "Getting Gold," by J. C. F. Johnson (3s. 6d.); "Mine Accounts and Mine Bookkeeping," by James Gunson Lawn (10s. 6d.); and "The Investigation of Mine Air," by Sir Clement Foster (6s.). Books by other publishers include "British Mining," by R. Hunt (Lockwood. 42s.); "Economic Mining," by C. W. Lock (Spon. 21s.); "Colliery Working and Management" (Lockwood. 15s.); and "Rock Blasting," by G. G. André (Spon. 5s.).

Mining concluded

THE MODERN CYCLE

Frame Construction. Wheel Building. Hubs and Gears. Brakes and Tyres. Components and Accessories

By H. J. BUTLER

IN the cycle factories of Coventry and Birmingham we have instances where the machine is built throughout, even including the tyres, now that various patents have lapsed; but usually, although completed machines leave the works, outside firms are depended on for such items as tubing, chains, balls, saddles, etc. Another class of factory is that where components or parts are made as well as completed frames. These are sold to dealers who assemble the different fittings together into the complete article. This *assembling* forms a large branch of the trade, and will be the form of manufacture most likely to interest the reader as being one he may himself adopt.

The Cycle and its Parts. Our bicycle of to-day consists of two wheels placed one before the other, mounted in a *frame* of steel tubing which carries the means for propulsion, seating, and steering. Three types of frame are illustrated—**60**, a road racing frame; **61**, lady's frame; and **62**, a tandem frame with rear seat for lady.

The frame consists of the following parts:

(*a*) The *top tube*. The horizontal member running from the seat to the steering.

(*b*) The *head*. The short member which receives the stem of the front forks.

(*c*) The *bottom tube*, running obliquely from the head to the bottom bracket.

(*d*) The *seat*, or *down tube*, running from the bottom bracket to the seat.

(*e*) The *back forks*, or *stays*, connecting the seat with the hind wheel hub.

(*f*) The *chain stays*, connecting the bottom bracket with the hind wheel hub.

(*g*) The *front forks*, the stem of which turns within the head tube (*b*).

The Frame of Ladies' Bicycles. The difference in dress necessitates a modification of the top tube [**61**]. This member, in the generality of machines, runs from the top of the head and sweeps downwards to a point just above the bottom bracket. Often it is connected by a stay to the bottom tube.

The Frame Lugs. The frame tubes are joined together by means of socket-shaped pieces called *lugs*, the junction being effected by brazing and internally strengthened by pieces called liners.

The lugs in a standard pattern frame are:

(*a*) The *top head lug*, joining the head and top tubes.

(*b*) The *bottom head lug*, joining the head and bottom tubes.

(*c*) The *seat lug*, joining the top and down tubes and provided with means of attaching the back forks, and split for adjusting the seat pillar which carries the saddle.

(*d*) The *bottom*, or *crank bracket*. This is provided with sockets for taking the down tube, bottom tube, and the two chain stays, as well as receiving the axle to which the pedals and their cranks are fastened.

(*e* and *f*) The two *chain stays* and the two *back forks* are generally connected together—sufficiently beyond the wheel to give a safe clearance—by a bridge in each case.

(*g*) The *back forks ends* may be brazed to the lower ends of the forks, but in many patterns both ends of the back forks are fixed by a bolt passing through them. A slot is provided for receiving the hind wheel axle.

(*h*) The two *front forks* are connected by a crown which also receives the fork stem.

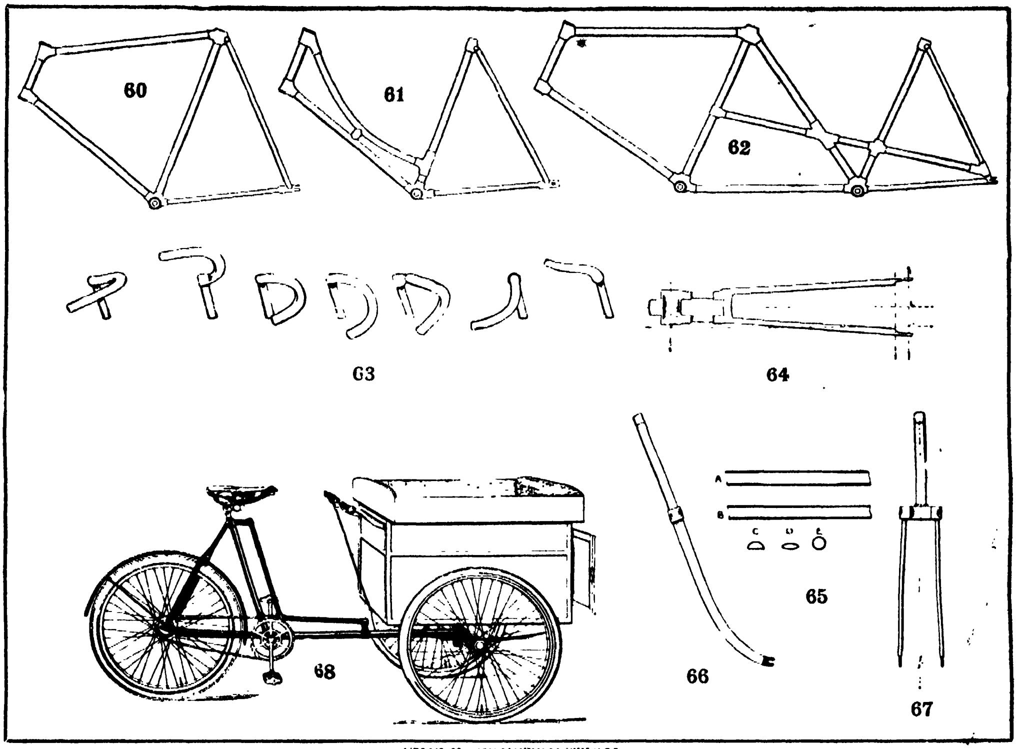
In a flush-jointed frame the above lugs are placed inside the frame tubes instead of the usual practice of placing them outside. A lug usually connects the handlebars with the handlebar stem and another connects the two portions of the seat pillar.

The Head. The head tube receives within it the stem of the front forks, and, again, inside the front fork stem we place from above the stem of the handle bars. These two stems are held tightly together by a clip immediately above the top head lug. The clip is provided with a bolt and nut, while the fork stem is split for a couple of inches at the back to allow of adjustment. A nut is also provided to prevent vertical play. It is usual to provide a steering lock, whereby the turning of the front wheel is arrested. This prevents damage when leaving the machine against a wall or curb.

There are numerous shapes of handlebars [**63**] brazed through the lug on top of the stem, and they are made to suit every taste. From the racing pattern, allowing of a low grasp placed forward, are intermediate patterns until we arrive at the full upturned lady's pattern which brings the hands above and behind the top of the head tube.

The Driving Gear. The modern bicycle is *rear-driven*—that is, the motion is transmitted through the hind wheel. By pressing down alternately on the pedals the cranks are rotated with their connecting axle which sets in motion the bracket chain wheel and, likewise, by means of the chain, the hub chain wheel.

The Cranks. The cranks receive at their lower ends the axle of the pedals. The latter may simply screw into the cranks. Care should be taken to see that a left and right handed thread is provided respectively, as although the pedals rotate round their own axle in the same direction, yet they are on opposite sides of the cranks, and the tendency will be, if opposite threads are not provided, for one of the pedals



CYCLE CONSTRUCTION

60. Diamond frame 61. Lady's frame 62. Tandem frame for lady and gentleman 63. Shapes of handlebars 64. Chain stays, bridge and bracket 65. Cycle tubing 66 and 67. Front forks 68 Carrier Tricycle

to work loose. The inner end of the crank is swelled out and pierced to receive the crank axle. A common method of fixing is by a tapering cotter pin which drives into a similar shaped keyway. Both have a flat side to prevent working loose. The cotter pin is pulled up tight by a small nut.

The Throw of Cranks. The length from crank axle centre to pedal axle centre is called the *throw*. Usually 7 in. will be found suitable for a rider with normal length of leg. Increase of this means greater leverage, but the feet have to move through a larger circumference, thereby speed is lost. For tall riders using a high gear, $7\frac{1}{2}$ in. is often used, and ladies find comfort when the throw is not more than $6\frac{1}{2}$ in.

The Chain and Chain Wheels. The power is not merely transmitted from one chain wheel to the other, but by the relationship as regards the number of teeth on each wheel, the number of revolutions of the hind wheel are greater than the revolutions of the cranks. If there are 16 teeth on the bracket chain wheel and 8 on the hub chain wheel, the hind wheel will revolve twice as often as the cranks.

The Gear. The gear of a bicycle is calculated in inches, and represents the diameter of the wheel that would be necessary to ensure the same rate of speed if the cranks were connected directly to the driving wheel hub. Thus, if we have 16 teeth in front and 8 at the back, together with a 28 in. wheel, we call the gear "56 in.," which is arrived at by dividing the number of teeth on the hub chain wheel into the number on the bracket chain wheel and multiplying by the diameter of the driving wheel. By multiplying again by $3\frac{1}{7}$ we get, approximately, the distance which the machine travels at one complete revolution of the cranks.

The Chain Line. It is absolutely necessary that the chain should run over the teeth on the chain wheels centrally, without any undue friction on either side. This is attained by a correct chain line, and is calculated at two points [see **64**].

1. From a line passing transversely through the centre of the back hub to a line passing through the centre of the chain wheel teeth.
2. From a line passing transversely through the centre of the crank bracket to the centre of the chain wheel teeth.

Both these measurements should be exactly the same, thereby ensuring that the two chain wheels will revolve exactly in the same line in the same way that the two road wheels should do. This chain line varies from $1\frac{5}{8}$ in. in racers, to $1\frac{7}{8}$ in. in roadsters with gear cases.

The Bracket Chain Wheel. The chain wheel is usually fixed by screwing it on to the inside of the crank boss, and the outer ring carrying the teeth can be made detachable, so that the gear may be increased or decreased by adding another ring of teeth.

The Hub Chain Wheel. This is screwed on to the back hub and rotated with it in the patterns of the last few years, but now, owing to the almost universal adoption of the free wheel, it forms part of the free wheel hub, and by means of either roller friction or a pawl the hub can rotate while the chain, cranks, etc., are at rest. The hub chain wheel should be of a sufficient circumference to accommodate not fewer than eight teeth. The larger this wheel the further from the centre lies the chain, consequently meaning greater leverage; also, the chain is not unduly curved. But we must limit the size of this chain wheel, as the larger this wheel is, the larger must our bracket chain wheel be in order to obtain the same gear.

The Chain. The chain may either be a series of solid blocks connected to side links by means of pins allowing of free movement as the links run round the chain wheels, or the side links may be connected by pins which pass through rotating rollers. The first type of chain is known as the *block* chain, and now finds little favour; the second is the much used *roller* chain, in which we have the advantage of rolling over sliding friction. The links are formed into an endless chain, by means of a bolt and nut which takes the place of one of the pins.

Pitch of Chain. The pitch is measured from the centre of one pin to the centre of the next—usually it is $\frac{1}{2}$ in.

Adjustment of the Chain. The chain when properly adjusted should show a very slight departure from the straight line. A loose chain may mount the chain wheel and cause disaster. The slot in the back fork ends allows of the hind wheel being pulled further away from the crank bracket. This is done by turning a nut at the end of the slot. Care must be taken to perform the operation equally on both fork ends, otherwise the alignment of the hind wheel may be destroyed.

Free Wheels. The roller type of free wheel is almost obsolete. When the chain ring is turning, a series of rollers are drawn by friction against the ring up inclined planes, and are jammed between the clutch and the ring, thus taking the hub, and consequently the road wheel with it. When free wheeling takes place, the rollers are released together with the contact between the chain ring and the free-wheel clutch.

In the ratchet free wheel the chain wheel is fitted internally as a ratchet wheel, while pawls are connected to the clutch. When the chain ring is revolving the pawls slip past, but when it is stopped either the pawls are free to drop by themselves, or they are forced home to their work by small coiled springs. These are various modifications of this main principle which are the subject of patents.

Pedal and Other Brakes. A back-pedalling brake is one in which retarding action is effected usually within the back hub by means of one cone wedging itself into another when pressure is exerted in the opposite direction to the usual pedalling force. Another variety of the same type of brake is in the form of a rim brake. This is brought into play by means of a tension rod connected with the crank bracket. Rim brakes are the type that have been adopted largely. Pressure is applied either by a system of levers and connecting rods, or by a Bowden wire, the power being applied by a small lever.

Variable Gears. Means are sometimes provided within the back hub whereby the gear may be altered at will. It is advantageous to lower the gearing when going up hill, and on a good level road one naturally wishes to increase the rate of speed. This may be effected when variable gear is fitted by merely pulling a lever and yet maintaining the same rate of crank rotation, although, of course, more power will be necessary for the higher gear. There are two and three-speed hubs, and usually on one gear (the high) the whole hub runs solid. The intermeshing of toothed wheels of varying numbers of teeth ensures different rates of speed in the same way as with the chain and its wheels. The modern gears are also fitted to allow of free wheeling.

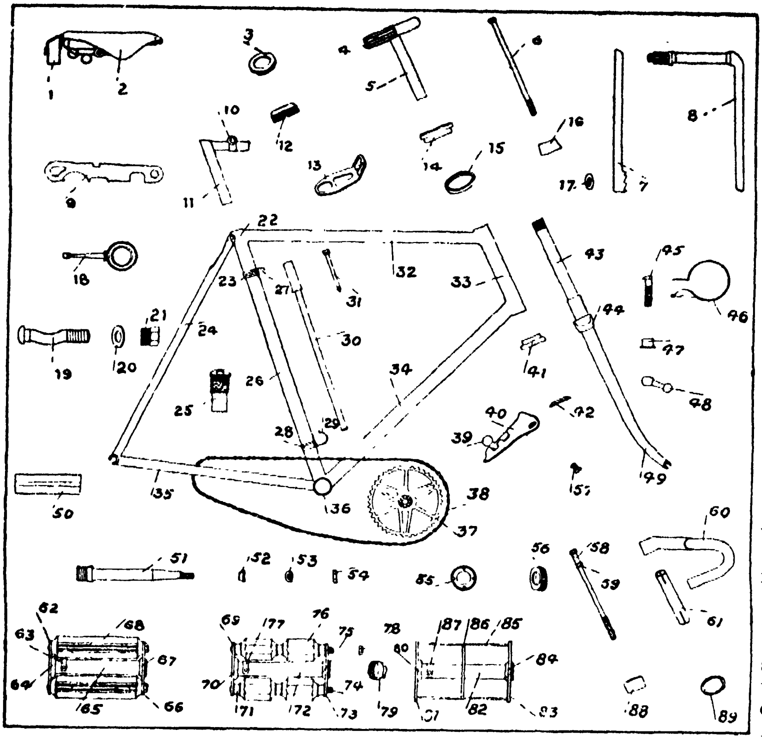
The Tubing. The frame is composed of weldless steel tubing [**65**], which implies that it is not merely sheet metal welded to form a pipe, but is worked up from the solid. Usually the section of the tubing is circular [**65** E], and varying in gauges according to the strength necessary, but the back forks and chain stays are usually of D section [**65** C], while the front forks are oval [**65** D]. Not only does the gauge vary, but in the same tube we may find the thickness increasing at the end. This is butted tubing, and when reinforced at both ends we have a *double-butted tube* [**65** A], the type used in the best machines. Taper gauge tube [**65** B] is often the material used in the front forks [**66** and **67**], the greatest strength being at the crown. Butted tubing obviates the necessity for using liners.

Wheels. The wheels consist of wire spokes inserted in metal or sometimes wooden rims, on which are placed the pneumatic tyres. Equal sized wheels allow of interchangeability of tyres, which is an advantage, as the wear on the back tyre is greater. Therefore, after a bicycle has run a considerable distance, the tyres may be exchanged. Wheels of 28 in. diameter are usual.

Spokes. Spokes are generally tangential to the hub, the direct-spoked wheel being out of date. Spokes may be the same gauge throughout or single and double butted. They are made stouter at the ends where the strength is necessary; the centre is lighter, and gives less air resistance. The spoke is prevented from passing through the hub flange by its head, and is attached, and its tension is regulated, by the thread and nipple and washer at the rim.

Rims. Steel rims are either hollow or solid, and are adapted for the different brands of tyres. A rim joint, when placed exactly opposite the tyre valve, can be made to balance it, and such a rim can be manufactured without heat.

Tyres. The pneumatic tyre consists of three portions: (*a*) The inner tube, made of rubber, lightly vulcanised and provided with a valve



69. CYCLE COMPONENTS

1. Tool bag 2. Saddle 3. Head adjuster 4. Handle grips 5. Handlebar 6. Expander bolt 7. Right crank 8. Left crank and axle 9. Spanner 10. Saddle clip 11. Seat pillar 12. Head lock ring 13. Lamp bracket 14. Outer top head cup 15. Inner ditto 16. Expander cone 17. Axle nut 18. Oil-can 19. Seat pillar bolt 20. Seat pillar washer 21. Seat pillar nut 22. Seat lug 23. Pump clip band 24. Back forks 25. Crank bracket lubricator 26. Seat tube 27. Pump clip fixed end 28. Pump clip band 29. Pump clip spring 30. Pump 31. Pump connection 32. Top tube 33. Head 34. Bottom tube 35. Chain stays 36. Crank bracket shell 37. Chain wheel 38. Chain 39. Steering lock socket bolt 40. Steering lock socket 41. Bottom head cup 42. Fork crown cone 43. Fork stem 44. Fork crown 45. Steering lock bolt 46. Steering lock band 47. Steering lock collar 48. Steering lock nut 49. Fork blades 50. Crank bracket sleeve 51. Pedal pin 52. Pedal cone 53. Pedal cone washer 54. Pedal cone nut 55. Crank bracket locking disc 56. Crank bracket inner disc 57. Steering lock socket screw 58. Reversible handlebar expander bolt 59. Reversible handlebar expander bolt nut 60. Reversible handlebar 61. Reversible handlebar stem 62. Inside end plate for rubber pedal 63. Pedal lubricating band 64. Pedal inside cup 65. Pedal centre 66. Outside end plate for rubber pedal 67. Pedal outside cup 68. Pedal rubbers 69. Inside end plate for rubber pedal 70. Pedal inside cup 71. Pedal distance piece 72. Pedal centre 73. Outside end plate for rubber pedal 74. Pedal rubber rod 75. Pedal outside cup 76. Divided pedal rubber 77. Pedal lubricating band 78. Pedal rubber rod nut 79. Pedal dust cap 80. Pedal inside cup 81. Inside end plate for rat-trap pedal 82. Pedal centre 83. Outside end plate for rat-trap pedal 84. Pedal outside cup 85. Pedal side plate 86. Pedal strut 87. Pedal lubricating band 88. Reversible handlebar top expander cone 89. Reversible handlebar collar

whereby the tyre may be inflated and retain the air pumped in—this valve passes through the other portions of the tyre and the rim; (*b*) the fabric on which (*c*) the outer vulcanised cover is mounted. These last two portions are solutioned together. Single-tube tyres have no distinct inner tube.

The tread of the outer cover varies from the mere strip of the racing tyre to the heavy tread of the roadster. Tyres may be retained by wires or by a beaded edge.

Building the Wheels. The number of spokes in a rear wheel is usually 40, while 32 suffices for the front wheel. There are mechanical contrivances for spacing the spoke holes in a rim, or they may be taken off from a spacing board or from an old wheel. The holes are then drilled, the delicate rim being properly supported, and the burr round the holes removed with a half-round file. The spokes are cut off to correct length. This is found by laying the rim on a level surface, and supporting the hub in its centre at its proper height, and then taking the required length.

Spacing the Front Spokes. The spokes are built into the wheel in the following manner. For a 32-spoke wheel mark two holes in the rim, leaving nine apart. Thread the ends of four spokes, and try them in position. Screw up the nipples till the hub is held exactly in the centre of the rim. Here we shall be able to see if we have measured with precision, for the spoke should not project beyond the rim; also, if threaded for the proper length, no threads will show beyond the nipple. If any alteration is necessary, we shall be able to make it in the remaining spokes. Sixteen spokes proceed from one side of the hub to the rim. At the rim the spoke heads are alternately inside and outside the hub flange. An equal number proceeds from the other flange in like manner, both sets spacing themselves on the rim alternately. After the first four spokes have been inserted, another four are fixed, leaving the same space apart as before, and so on till the wheel is built.

Spacing the Hind Spokes. The 40 spokes for this wheel are first spaced by placing two spokes in the hub flange six holes apart, one with head inside and the other outside; the spokes are crossed, and reach the rim one hole apart. Miss two holes in the hub flange below each of the first spokes, and repeat the operation as before. The fifth spoke leaves the hub with one hole between it and the next, and runs in the same direction as the spoke from which it was spaced on the hub, and proceeds to the rim, entering the same three holes from its fellow. Complete the whole of one side first by putting 10 spokes in one direction. The remaining eight spokes running from the same hub flange are placed in the opposite direction, and crossed as before mentioned. The other hub flange, with its 16 spokes, is similarly treated.

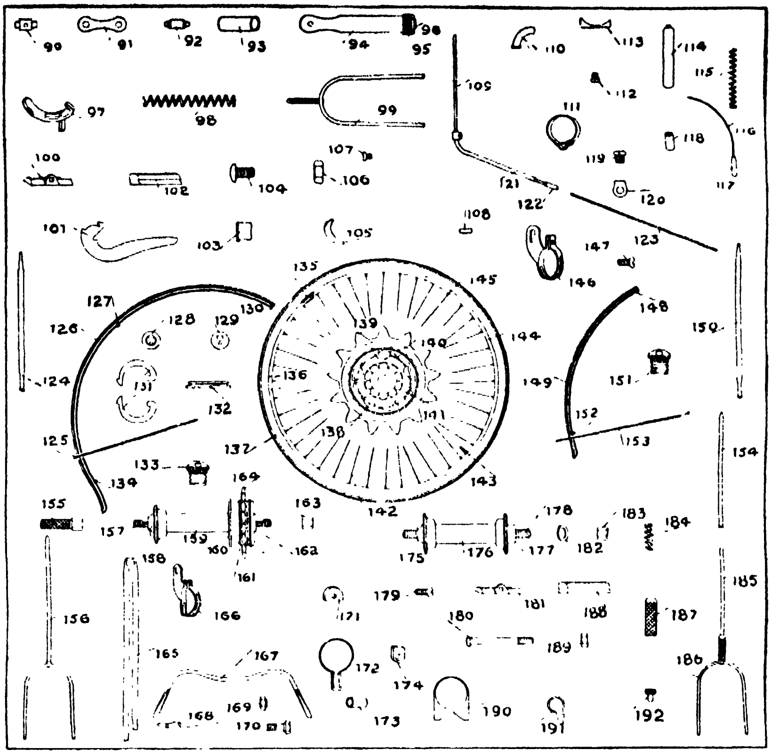
Wheel Truth. The wheels are trued by the careful tightening or slackening of the nipples. Not only have we to see that the rim

is equidistant all round its circumference from the centre, but that its two faces lie in parallel planes. To cure a defect in circularity the spoke at the fault and directly opposite is adjusted.

Frame Building. We shall suppose that an outline drawing of the frame has been made, preferably on a sheet of metal, so as to test the true relationship of the parts while hot, and in order that we may know the exact length of the tubes before brazing in the lugs.

The Components. Before constructing the frame we shall need, beside our lengths of tubing, a set of components which are as follows:

1. The front wheel hub.
2. The back wheel hub, with chain-wheel.
3. The crank bracket, with cranks, axle and chain-wheel.
4. The head tube, with its top and bottom lugs and ball races; front fork crown, lamp bracket, etc.
5. Pair of pedals.
6. Chain stay bridge.
7. Chain stay ends.
8. Back fork bridge.
9. Back fork eyes.
10. Seat lug.



70. CYCLE COMPONENTS

90. Back brake bracket link rivet 91. Back brake bracket link 92. Back brake bracket link rivet 93. Back brake inside telescopic tube 94. Back brake adjustment 95 Back brake adjuster 96 Back brake adjuster nut 97. Back brake spring stop 98. Back brake bracket spring 99 Back brake forket 100. Brake shoe 101 Cable brake lever 102. Brake block 103. Cable brake fulcrum 104. Brake shoe bolt 105 Cable brake snail 106. Brake shoe nut 107. Cable brake cover plate screw 108 Cable snail nipple 109. Back brake head rod 110. Cable brake tubular guide 111. Cable bottom tube clip 112. Cable brake cover plate screw 113. Cable brake cover plate 114. Cable brake spring cover 115. Cable brake handlebar spring 116. Handlebar cable 117. Cable brake head tube nipple 118. Cable brake spring ferrule 119. Brake forket rod clip bolt 120. Brake forket rod clip 121. Back cable frame tube 122. Back brake rod and cable union 123. Back brake long rod 124. Front brake head tube 125. Back mudguard stay 126. Back mudguard 127. Mudguard fork spring 128 Outer chain adjustment plate 129 Inner chain adjustment plate 130. Mudguard chain stay spring 131 Chain ring lock springs 132. Free wheel ball race 133. Hub lubricator 134. Mudguard stay spring 135 Rim joint 136. Front rim 137. Tyre 138. Free wheel pawls 139. Free wheel chain ring 140. Free wheel ball cage 141. Back hub end 142 Spokes 143 Valve 144 Back rim 145. Nipples 146. Back forket guide 147. Fork and chain stay clip bolt 148. Mudguard fork spring 149. Front mudguard 150. Back brake head tube 151. Hub lubricator 152. Mudguard stay spring 153. Front mudguard stay 154. Front forket rod 155 Step 156. Front forket for rolling lever brake 157. Back wheel spindle 158. Hub adjusting cone 159. Back hub 160. Back hub end 161. Fixed chain ring washer 162. Hub fixed cone 163. Wheel spindle nut 164. Fixed wheel chain ring 165. Brake yoke 166. Front forket guide 167. Rolling brake lever 168. Dwarf brake lever 169. Dwarf brake lever clip nut 170. Dwarf brake lever clip bolt 171. Forket guide nut 172. Dwarf brake lever clip 173. Rolling brake lever distance piece 174. Rolling brake lever D washer 175. Hub adjusting cone 176. Front hub 177. Hub fixed cone 178. Front wheel spindle 179. Fork and chain stay clip bolt 180. Rolling brake lever bolt 181. Brake shoe 182. Front wheel washer 183. Wheel spindle nut 184 Cable brake moderator spring 185. Front forket rod 186. Front brake forket and moderator stud 187. Cable brake moderator spring box 188. Brake block 189. Rolling brake lever nut 190. Rolling brake lever clip 191. Rolling brake lever fulcrum 192 Cable brake moderator stud

These and the other numerous parts of a modern bicycle are illustrated in **69** and **70**. We have selected the parts of a Rudge-Whitworth bicycle as typical.

Chain Stays. The chain stays are cut to length, so that with the short bridge tubes (those running from the bridge to the crank bracket) and the bridge in position we shall have not less than $\frac{3}{4}$ in. between the tyre and the inside of the bridge, the back wheel spindle being at the commencement of the slot. The chain stay ends are brazed to the chain stays, and the short bridge tubes are brazed to the bridge lugs.

Back Forks. The seat lug, or back fork eyes are then fitted to the back forks, and brazed.

The chain stays, with their brazed-in ends are tried to the back wheel and spindle to see that the stay end faces are parallel, and that the stay lines correctly each side of the wheel. But only the *trying* should be conducted with the wheel in position, as any attempt to adjust any error will injure the parts. The necessary alterations should be made at the bench, and it is a safe rule to remember that a tube must be gripped or a blow given by something softer in nature than the part undergoing the operation. Tube clamps are therefore constructed of hard wood, and a wooden mallet must be used in most cases.

Fitting up the Frame. The bottom head lug has the head and bottom tubes fitted to it, and as the bottom tube butts right on to the head tube inside the lug, a piece must be hollowed out to allow of the two tubes being brought close together. We next place in position the top head lug and into it fit the top tube, hollowing

out the latter in the same manner as the bottom tube. Knock on the crank bracket, and into it the seat tube; lastly, fit the seat lug in position, hollowing out having been performed at the end of the top tube, where it touches the seat tube and the end of the bottom tube to miss the end of the seat tube. Therefore both bottom and top tubes are hollowed at each end.

The Use of the Mandrel. If a tube be too small for its lug we force the tube gradually on to a mandrel held in the vice. The tube should be revolved as it is knocked forwards in order that the enlargement required may be performed equally all round. A caulking chisel is also used to ensure that the lug shall fit absolutely all round its tube.

Brazing. Being quite sure that the frame follows accurately the drawing as regards every measurement, and that the various angles formed by the tubes with one another are as drawn, we may proceed to braze the frame together. Brazing is a process effected by means of an internal charge of brass or spelter and borax. During the heating, brazing pegs are inserted at the joints. Parts, such as threads, where it is necessary that the brazing mixture should not run, are coated with blacklead. Care must be taken not to burn or overheat the tube. Where the tube has not an outlet, a tiny hole must be punched to allow of the escape of heated air. Brazing is also effected by steeping the specially prepared frame in a vat of molten brass.

Completing the Chain Stays. The bridge with its short tubes and the two stays with their ends are first fitted and then brazed together with the back wheel spindle in position to give them their proper relationship, after which they are united to the proper lugs on the bottom or crank bracket. While brazing the stays into the crank bracket we must tie the frame from the spindle to the seat lug. If the back stays are of the detachable variety, it will be convenient to bolt one in position.

Testing the Chain Line. Clean out the crank bracket, and place the cups and spindle in position, and fit on the bracket chain wheel. Then place the hind wheel in position with its chain wheel, and place a straightedge along the faces of each of the chain wheels.

Building the Front Forks. The fork ends may be either slotted or drilled for the front wheel spindle; the former method is best, as it prevents *springing* in the spindle. Clean out the slots or holes and braze on the ends. Having allowed for the $\frac{3}{8}$ in. clearance, as in the chain stays, for the wheel, braze on the fork crown. The fork stem is then brazed to the crown. Care should be taken that each fork blade is exactly the same length, that the side clearance from the rim is the same, and that it unites with the stem exactly as marked out on the drawing. The side and front view of a complete pair of front forks is shown in 66 and 67.

Handlebars. The handlebars may be fitted to the handlebar stem by a lap joint or a lug. The lap joint is merely wrapped round the centre of the bar and brazed; but with the lug we have a strong and neat fixing such as is used in the frame proper.

The Seat Pillar. The seat pillar has an alternative fixing, as the handlebars, and we must be careful to see that it forms a similar angle to that formed by the top and down tubes.

Testing the Frame. Too much attention cannot be given to making absolutely sure that the frame is true. It must follow the drawing in every detail, all lengths, overall length and angles being as set out. The wheels are correct before mounting in the frame; and we must test our work to see that they are centrally placed. Another important matter is that the centre line of each of the tubes lies in the same plane. A straightedge placed on the face of the bottom bracket at one end should be parallel to the edge of the tube up which it is placed, the space between the straightedge and tube being tried by a pair of inside callipers. After the testing has been completed and the frame found correct, it is filed up and cleaned with emery.

Plating and Enamelling. The parts usually plated are the handlebars, seat-pillar, front fork crown, fork tips, chain wheel, cranks, pedals, spokes, wheel rims, and all nuts. Plated parts are finished with the polisher's bob, so that except in corners where the bob could not reach we need not trouble about much high finish.

Enamelled parts must be carefully finished with emery, and the better the surface the better finish will the enameller be enabled to produce. Being quite sure that the parts are free from grease, the tubes are given a coat of enamel, either by dipping or by hand. The surplus having been removed, the frame is hung up in an oven and subjected to a temperature of about 350° for a couple of hours. This coat is flatted with pumice dust and the enamelling and heating repeated. A third coat gives a better finish.

Assembling the Finished Parts. We first proceed to fit up the bottom bracket, taking care to protect the freshly-enamelled frame. When the cones, balls and axle are in position we proceed to fit on the cranks, driving up the cotter pins securing them with the nut provided for the purpose. The head is then fitted up with the balls in their respective races, and the handlebar clip, lamp-bracket, and lock nut placed in position. The wheels are then put in, care being taken before final adjustment to see that they track. A properly fitting chain allows about $\frac{1}{2}$ in. play of the cranks. Then we fix on the mudguards and brake, of whatever pattern used, the seat pillar with its saddle, and, lastly, the gear case if used; and if a lady's machine, a dress guard.

Bearings. One of the most important factors in deciding the sweet running of a cycle is the design of the bearings and their lubrication. A bearing is to be found wherever movement occurs, such as the wheel, crank and pedal axles, and for many years past they are and have been—ball bearings.

Ball Bearings. A ball bearing consists of a series of steel balls working in a race, which is formed between a cone on the one hand and an encircling cup on the other. In a plain bearing these two surfaces would work directly on one another ; but in ball bearings we have the friction transferred to the small points on the surface of the balls, and rolling friction substituted for sliding friction.

Types of Bearings. Bearings may be classified according to their type or method of adjustment. The balls of the bearings work between a cone, fixed generally to the axle, and a cup screwing into a corresponding part of the machine. In the crank bracket the cone is affixed to the crank axle and revolves with it, while the cup is screwed into the shell of the bracket and remains stationary. In the wheels this is reversed ; the axle and cones are fixed and the two cups revolve.

Adjustment Variations. Bearings are either cone or disc adjusting. In a cone variety hub the cups are fixed into the case of the hub. One cone is attached permanently to the hub axle, while that on the other side is threaded on so that it is capable of adjustment and at the same time allows of the passage of the balls to and from the ball race when required.

Fitting Up a Ball Bearing. It will be readily understood that by sliding the axle in the hub and by unscrewing the movable cone, the balls may be slipped in. In putting the bearing together the side with the fixed cone would be inserted first. Then, after holding that up to its place and turning the wheel over, the other side is found with the movable cone projecting out ready for the balls, after the insertion of which the cone is screwed up into position.

Disc Adjustment. In the disc adjustment bearing or cup adjustment, as it is sometimes called, we have a fixed cone on each end of the axle. The cups screw bodily into the case of the bearing.

Width of Bearings. In the cone type of bearing the cones are outside the cups, while in the disc type the cones are inside. It is well to point out that the distance between the ball races, and consequently the width apart of the bearings, should be as wide as possible to resist the one-sided strain that we get in the chain-driven bicycle. The disc adjusting type gives a slightly greater width of bearing, and where it is used in the bottom bracket, it is a good plan if the bracket chain wheel can be dished inwards towards the centre, thus bringing the strain more central—nearer the ideal position of the driving chain.

Accessories. By accessories we include such items as the saddle and tool bag, lamp, bell or horn, tools such as spanners, oil-can, inflator, luggage carrier, repairing outfit, trouser and toe-clips.

Saddle. There are many forms of saddles, and they are made to suit any purse. A good saddle should be made from selected leather, be adjusted to allow the cyclist to rest on the broad part and reach the handlebars and pedals without any suspicion of stretching. It should be mounted on springs that with their elasticity will prevent bouncing on the one hand and a hard seat on the other. The peak is merely to retain the rider from getting away from his proper seating, and is not meant to receive any great strain. There are special forms of saddles for racing men which give great freedom of action, and the most fastidious can choose various types of hygienic saddles. Means are provided for taking up the slack, should the saddle through exposure and heavy usage warrant it, and the judicious application of occasional dressing will all help to lengthen the life of that part of the machine which, with the tyres, gives comfort to the cyclist as he rides.

Lamps. Most cyclists use the oil lamp, but acetylene gas gives a far more powerful light. Candle lamps are also manufactured. To burn well, a lamp should be kept thoroughly clean. This is especially the case in a gas lamp. A cheap lamp is no economy, for a light is a legal necessity at night, so we must pay a fair price if we are to expect a lamp that will keep alight in the roughest weather and always to be depended on.

The Tricycle. The tricycle is a slower and heavier machine but free from side slip. The one essential difference, apart from the number of wheels, is the presence of the balance or differential gear on the hind axle, which allows of the outer wheel revolving at a greater speed than the inner one, a necessity when rounding a curve.

The Modern Use of the Tricycle. The tricycle is now chiefly used as a carrier [68], having a box of varying descriptions mounted in the frame. The box may be on the front axle with the handlebar fixed to the top back rail of the body, or on the hind axle, when the steering is usually effected by stirrup handles. In a *bicycle carrier* small boxes are fitted each side of the hind wheel.

Tandems. The tandem frame [62] is constructed practically under the same conditions as the bicycle frame, and is arranged for a lady either front or behind, or with both seats for men. The tubing used is of a heavier gauge, and we have another set of chain and back stays, down and top tubes, to provide as well as the extra handlebar and stem, seat-pillar, bracket, chain wheel and chain. Other multiseated types are used for path pacing, but are being discontinued owing to the advent of the motor bicycle.

Continued

COMPARATIVE LITERATURE

A Note on Comparative Literature. American Writers. Ancient and Foreign Classics for English Readers. Books that Must, May, and Need Not be Read

By J. A. HAMMERTON

WHAT is technically known as "comparative literature" is a vitalising factor in international goodwill and the fellowship of nations. To know only the literature of our own country is no small thing, but we must know also something of the other literatures, else we are in much the same position as the man who has travelled throughout these green islands of our race and has never set foot on foreign soil. He is the least competent person to tell us of his own land, lacking as he does all standards of comparison. The reader who knows only his national literature is not quite so insular, since he has at least spent time in the company of writers who, for the most part, reflect a universality of culture; but it behoves the serious student to acquire some knowledge of foreign literature, preferably in the original, even if his linguistic attainments be limited to one foreign language—French or German. There is, however, an abundance of good translations.

Thus, many of the best novels of recent years have come to us from France, Germany, Russia, and Italy. Some of the soundest criticisms of English literature are the work of French writers. In the study of comparative literature, the French are undeniably in advance of ourselves; and a short time ago a most useful treatise on the subject was written by M. Frédéric Loliée. This has been translated by Mr. Douglas Power, M.A., and published under the title of "A Short History of Comparative Literature from the Earliest Times to the Present Day" (Hodder & Stoughton. 6s.). There can be no doubt, of course, that it is best to read a foreign book in the language in which it was originally written; but the reader's knowledge of that language must be a competent knowledge. Where this is lacking, competent translators are the more desirable from every point of view. The English Bible is a translation, so we may well accept Homer at second hand.

AMERICAN LITERATURE

Although it is true in the main that American literature is only a province of English literature, we have not dealt with American writers in our preceding studies, reserving them for separate notice. Apart from the influences of environment, the sources of American literature may be truthfully described as English and German. In America, of recent years there has been a much greater study of the Greek and Roman classics, while Transatlantic scholarship is rivalling that of England, particularly in regard to the literature of the Elizabethan period. We must now pass in review the names of those American authors with whose work every English reader should be acquainted.

Poetry. In poetry, the outstanding names are those of WILLIAM CULLEN BRYANT (b. 1794; d. 1878); RALPH WALDO EMERSON (b. 1803; d. 1882); HENRY WADSWORTH LONGFELLOW (b. 1807; d. 1882); JOHN GREENLEAF WHITTIER (b. 1807; d. 1892); EDGAR ALLEN POE (b. 1809; d. 1849); OLIVER WENDELL HOLMES (b. 1809; d. 1894); WALT WHITMAN (b. 1819; d. 1892); JAMES RUSSELL LOWELL (b. 1819; d. 1891); CHARLES GODFREY LELAND (b. 1824; d. 1903); RICHARD HENRY STODDARD (b. 1825; d. 1903); BAYARD TAYLOR (b. 1825; d. 1878); FRANCIS BRET HARTE (b. 1839; d. 1902); JAMES WHITCOMB RILEY (b. 1853); and CINCINNATUS HINER MILLER ("Joaquin Miller") (b. 1841). A number of these poets are no less, and some are more, distinguished as prose writers.

Prose Fiction. American prose is characterised by much didacticism; its earliest examples bear the impress of Steele and Addison and the Puritan divines. In its later phases it has, however, lacked neither fancy nor humour, the humour being especially racy of the soil. Perhaps no name more representative of American letters could be mentioned than that of "Mark Twain," SAMUEL LANGHORNE CLEMENS (b. 1835), who is essentially a humorist, with a vein of seriousness cropping out at times above the surface of his humour. The short story has been brought nearer to perfection in America than it has in England. Taking the writers of fiction in chronological order, the following may be accepted as representative: JAMES FENIMORE COOPER (b. 1789; d. 1851), author of "The Last of the Mohicans" and other tales of Red Indian life; NATHANIEL HAWTHORNE (b. 1804; d. 1864), author of "The Scarlet Letter"; OLIVER WENDELL HOLMES, author of "Elsie Venner"; EDGAR ALLEN POE, an absolute master of the short story; HARRIET BEECHER STOWE (b. 1811; d. 1896), author of "Uncle Tom's Cabin"; FRANCIS RICHARD STOCKTON (b. 1832; d. 1902), author of "Rudder Grange"; THOMAS BAILEY ALDRICH (b. 1836), whose "Queen of Sheba" is one of the greatest of short stories; WILLIAM DEAN HOWELLS (b. 1837), who shares with HENRY JAMES (b. 1843) the honour of being at the head of living American novelists, much as Meredith and Hardy are prominent in England; GEORGE WASHINGTON CABLE (b. 1844), the author of "Old Creole Days"; JOEL CHANDLER HARRIS ("Uncle Remus") (b. 1848); FRANCIS MARION CRAWFORD (b. 1854), who, though born in Italy, and devoting his talents to the description of Italian life, may be ranked as an American; HAROLD FREDERIC (b. 1856; d. 1898); GERTRUDE

ATHERTON; and EDITH WHARTON (b. 1862), whose "Valley of Decision" and "House of Mirth" are among the best examples of the novel, while her tale "The Descent of Man" shows her to be one of the best of short story writers now living.

Criticism and Philosophy. Of American essayists, critics, and philosophers, much might be written, especially of BENJAMIN FRANKLIN (b. 1706; d. 1790); WASHINGTON IRVING (b. 1783; d. 1859); RALPH WALDO EMERSON; JAMES RUSSELL LOWELL; OLIVER WENDELL HOLMES; and HENRY DAVID THOREAU (b. 1817; d. 1862). Of more recent writers, in addition to W. D. HOWELLS and HENRY JAMES, may be cited EDWARD EVERETT HALE (b. 1822); THOMAS WENTWORTH HIGGINSON (b. 1823); CHARLES ELIOT NORTON (b. 1827); WILLIAM JAMES ROLFE (b. 1827); WILLIAM WINTER (b. 1836); HAMILTON WRIGHT MABIE (b. 1846); and AGNES REPPLIER (b. 1851).

Science and History. In the world of science the name of the Swiss naturalist, JEAN LOUIS RUDOLPHE AGASSIZ (b. 1807; d. 1873), may be claimed as American. American historians of note include GEORGE BANCROFT (b. 1800; d. 1891); JOHN LOTHROP MOTLEY (b. 1814; d. 1877); WILLIAM HICKLING PRESCOTT (b. 1796; d 1859); and GEORGE TICKNOR (b. 1791; d. 1871), whose "History of Spanish Literature" is one of the best works on that difficult subject. Some acquaintance with the works of every writer named is desirable in anyone who would be considered "well read."

ANCIENT CLASSICS

Greek Literature. An excellent little primer on the "History of Greek Literature" is that by Sir Richard Jebb (Macmillan. 1s.). The study will be the more profitable if it is made supplementary to a study of the history of Greece, for which purpose we would commend W. Smith's "Student's Manual of Greek History" (Murray. 7s. 6d.). One further point has to be borne in mind, and that is the importance of a knowledge of mythology. This in itself is a wide subject, but some acquaintance with it is a primary essential for all who wish to understand the language of the classics, modern as well as ancient. There is a useful little handbook of mythology by Thomas Bullfinch (Routledge. 1s.).

The student's next concern will be with particular authors: Homer, the father of the epic; Hesiod, poet of men as Homer was poet of the gods; Theocritus, the writer of idylls; Pindar, the lyric poet; Æschylus, Sophocles, Euripides, the writers of tragedies; Aristophanes, the writer of comedies; Plato and Aristotle, the philosophers; Xenophon, Plutarch, Thucydides, and Herodotus, the historians; Demosthenes, the orator; Lucian, the satirist; and others. We know of no better introductions to the study of these masters than the "Ancient Classics for English Readers" (Blackwood. 28 vols., 2s. 6d. each). Of the "Iliad" and the "Odyssey" of Homer, Chapman's versions still maintain a general excellence despite many rivals; and one may here commend Gladstone's primer on Homer (Macmillan. 1s.). For texts and translations of the other writers we must refer the student to the catalogues of Messrs. Frowde, Clay, Macmillan, and Bell.

Latin Literature. We know of no better introduction to the study of Latin literature than the manual by Professor J. W. Mackail (Murray. 3s. 6d.). But A. S. Wilkins's little primer (Macmillan. 1s.) and Smith's "Student's Rome" (Murray. 7s. 6d.) will prove most helpful. To come to particular works: the philosophical poetry of Lucretius; the lyrics of Catullus; the orations of Cicero; the epic strains of Virgil; the odes and satires of Horace; the voluminous verse of Ovid; the histories of Cæsar, Livy, Tacitus, Sallust and Suetonius; the satires of Persius, Juvenal, and Apuleius; the philosophical writings and plays of the younger Seneca; the comedies of Plautus; the natural history of the elder Pliny; the epistles of the younger Pliny; the epigrams of Martial; the rhetoric of Quintilian; the writings of Tertullian, the first of the Latin Fathers—these, one and all, may well claim patient study. Apart from the catalogues of the educational publishers already mentioned, J. E. B. Mayor's "Bibliographic Clue to Latin Literature" will be found of material assistance to the student, whether the quest be a sound text or a competent translation.

FOREIGN CLASSICS

Italy. After a good grounding in the literature of Greece and Rome, the student will turn naturally to the literature of modern Italy, beginning with Dante, whose "Divine Comedy," written at the opening of the fourteenth century, links the ancient with the modern world, and marks the beginning of what is called the Renaissance. As a nucleus of this study, Richard Garnett's "History of Italian Literature" (Heinemann. 6s.) and Lewis Einstein's "The Italian Renaissance in England" (Macmillan), could not be improved upon, and much help through the tangled maze of an important period of European development will be derived from the abstract of John Addington Symonds's colossal history of "The Renaissance in Italy," written by Alfred Pearson (Smith, Elder. 7s. 6d.). One may trace the line of Italian literary development from Dante through the poetry of Petrarch, Ariosto, Guarini, Tasso, Marini, Alfieri, Monti, Manzoni, Leopardi, Metastasio, Carducci, and Rossetti; the tales and novels of Boccaccio, Bandello, Manzoni, Gabriele d'Annunzio, Verga, Fogazzaro, and Mathilde Serao; and the prose of Machiavelli, Guicciardini, Castiglione, Benvenuto Cellini, Bruno, Leopardi, Silvio Pellico, and Villari.

France. French literature is, from a strictly literary standpoint, of the first importance. One can have no more reliable guide in this study than Professor Dowden's handbook (Heinemann. 6s.) or Professor Saintsbury's "Short History of French Literature" (Clarendon Press. 10s. 6d.). Leaving "the shores of old romance" sacred to such works

as the "Chanson de Roland" and the "Roman de la Rose," we may briefly indicate the vast stores of literary wealth in the language of our nearest neighbours by mentioning the histories of Froissart, De Comines, Thierry, Guizot, Thiers, Michelet, and de Tocqueville; the poetry of Villon, Ronsard, Malherbe, Lafontaine, Boileau, André Chenier, Lamartine, Béranger, Hugo, Alfred de Musset, Leconte de Lisle, Beaudelaire, Théophile Gautier, Sully Prudhomme, and François Coppée; the wit of Rabelais, Voltaire, la Rochefoucauld, Chamfort, Marot, and Montesquieu; the philosophy of Montaigne, Descartes, Beyle ("Stendhal"), Rousseau, Condillac and Condorcet; the plays of Corneille, Racine, Molière, Scarron, Crébillon, Beaumarchais, Sardou, Hervieu and Maeterlinck; the thoughts of Pascal and Joubert; the novels and tales of Marguerite de Valois, Le Sage, Voltaire, Hugo, Bourget, Balzac, Boisgobey, Prévost, Dumas, Flaubert, Daudet, Zola, Merimée, Maupassant, the brothers De Goncourt, Murger, Georges Sand, Eugene Sue, Erckmann-Chatrian, Jules Verne, Pierre Loti, René Bazin, and "Gyp"; the letters of Mme. de Sévigné, Mme. de Staël, Mlle. de Lespinasse, and De Sénancour; the fables of Perrault and Lafontaine; the writings of Renan; the sermons of Bossuet, Fénelon, and Massillon; the oratory of Mirabeau; the acute critical work of Sainte-Beuve, Boileau, Diderot, Taine, Faguet, Jusserand, and Brunetière. To the reader with a knowledge of the French language we would commend "Blackie's Little French Classics," in which the cream of the literature is reprinted and carefully annotated.

Germany. German literature is another vitally important section of European letters. It has had a profound effect on both English and American thought. It is rich in romance, poetry, history, philosophy, religion, fiction, and works for the young. The English student is advised to begin his study of the subject with two works by Professor Charles H. Herford—"Studies in the Literary Relations of England and Germany" (Cambridge University Press. 9s.); and "A Short History of German Literature" (Heinemann. 6s.). First come the tales of the Nibelungs and the songs of the Mastersingers, which form such an important groundwork for modern German music, and especially the music of Richard Wagner. Next in importance from a chronological standpoint come the sermons and other compositions in prose and verse of Luther, Zwingli, and their fellow reformers. From this standpoint may be followed the course of German philosophy in the writings of Leibnitz, Kant, Fichte, Schelling, Hegel, Herbart, Schopenhauer, Von Hartmann, and Nietzsche; the evolution of poetry and the drama in the works of Klopstock, Lessing, Wieland, Herder, Schiller, Goethe, Bürger, Kleist, Körner, Arndt, Rückert, Uhland, Heine, Wagner, Kotzebue, De la Motte Fouqué, Chamisso, Sudermann, Hauptmann; the theological writings of Reinhard, Schleiermacher, Neander, Strauss, Dollinger, Ritschl, Wellhausen, and Haeckel; the historical studies of Gervinus, Ranke, Niebuhr, Boeckh, and Mommsen; the novels and tales of Goethe, Tieck, Novalis, Hoffmann, Jean Paul Richter, Auerbach, Gustave Freytag, Fritz Reuter, and Gottfried Keller. The philological and scientific writings of German origin are far too numerous even for the barest mention.

Spain. The literature of Spain is the theme of a well-written monograph by J. Fitzmaurice Kelly (Heinemann. 6s.) After consideration of the "Chronicle of the Cid," the oldest epic in a Romance language, and the romances of chivalry, such as the "Amadis de Gaula," the names that the English student can least afford to pass over are those of Montemayor, Cervantes, Lope de Vega, Mendoza, Herrera, Calderon, Camoens, Gongora, Juan Valera, and Palacio Valdés. It is in particular with reference to the history of the drama that Spanish literature is worthy of study. That its influence on English letters has been considerable may be gleaned from F. W. Chandler's "The Picaresque Novel in Spain" and J. G. Underhill's "Spanish Literature in the England of the Tudors" (Macmillan).

Russia. Russian literature, as represented in the work of Gogol, Poushkin, Oneguin, Lermontoff, Dostoievsky, Turgenieff, Tolstoy, and Gorky, has exercised considerable influence on European literature generally. Charles E. Turner's "Russian Literature" and "Modern Russian Novelists" and Waliszewsky's "Russian Literature" may be consulted.

Scandinavia. Scandinavia is also playing a great part in the formation of modern literature. The dramas of Henrik Ibsen and the novels and plays of Björnson Björnstjerne represent Norway's contribution. Denmark can boast the powerful literary criticisms of George Brandes; and Holland the penetrating novels of Maarten Maartens.

WHAT TO READ

Books that Must be Read. The student who has companied with us thus far is already acquainted with the books which we consider must be read by all who desire to have a substantial knowledge of English literature. Here we purpose offering no more than a few concluding hints.

The obvious reply to the question, "What are the books that must be read?" is, "The Best Books." But "the best books" for one are not "the best books" for another. Remember "the personal equation" of which we spoke at page 105. In the voice of many counsellors there is wisdom; but this wisdom has to be distilled by the person who hopes to profit from it.

This is but one of many reasons why we consider the lists of "the best books" that have been drawn up from time to time by well-known men are positively harmful if taken as of universal application. At the same time it is quite obvious that, as Ruskin once wrote, "a well-trained gentleman should know the literature of his own country and half a dozen classics thoroughly." The rest may wait on

inclination. We are at least on firm ground in saying that the study of literature for educational purposes is likely to be of the greatest value if it is based on a knowledge of literary history. The course, then, which we advise the student to pursue is to acquire a good "grounding" in general history, and then to study a good handbook to literary history such as the Lectures of Frederick Schlegel (a translation of which is to be found in "Bohn's Library") or the "Short History of Comparative Literature," by Frédéric Loliée, already mentioned. Of the other literary histories which he will find suggestive, first place may be claimed for Taine's "History of English Literature" (translated by H. Van Laun, and published by Chatto & Windus in four volumes, at 2s. net).

The books in English that must be read by everyone should include the Bible; Chaucer's "Canterbury Tales;" Spenser's "Faëry Queen;" the whole of Shakespeare; Milton's "Paradise Lost," "Comus," and the shorter poems; Bunyan's "Pilgrim's Progress;" Swift's "Gulliver's Travels;" Defoe's "Robinson Crusoe" and "Moll Flanders;" Goldsmith's "Vicar of Wakefield" and his two comedies; Sheridan's plays; Byron's "Childe Harold;" the greater part of Scott's poems, Wordsworth, Keats, Burns, Gray, Tennyson, Browning and Swinburne; Lewes's "History of Philosophy;" Gibbon's "Decline and Fall of the Roman Empire;" Bacon's "New Atlantis," "Novum Organum," and "Essays;" the Essays of Addison, Macaulay, Lamb and Hazlitt; Green's "Short History of England;" Carlyle's "Past and Present" and "The French Revolution;" Mill's "Political Economy;" Boswell's "Life of Johnson;" the novels of Fielding, Scott, Kingsley, Thackeray, Dickens, George Eliot, several of Trollope, Meredith and Hardy; and in foreign literature Homer, Plutarch, Virgil, Horace, Dante, Rabelais, Cervantes, Molière, Montaigne, Goethe, Schiller, Voltaire, Hugo and Balzac.

Books that May be Read. Here we pass to less certain ground, but we may claim that throughout our studies considerable care has been taken to specify, as their names have occurred, the works of many great writers which might be left entirely to the inclination of the general reader, though imperative to the student. For instance, we would have every "well-read" man know all the best plays of the Elizabethan dramatists, as these are to be found in the "Mermaid Series;" but we are far from saying that this is not optional to the general reader, though it is imperative to the student. So with such classics as "The Wealth of Nations" and "The Origin of Species." The gist of Adam Smith's philosophy and of Darwin's science is absorbed in one's general reading; by which we mean that both of these writers have so influenced their contemporaries and their successors that few intelligent people of the present day are ignorant of their teachings, even though they may not have read their works. This is no excuse for neglecting either; but the man who has not read "Hamlet" or "Paradise Lost," let us say, has an unfurnished chamber in his mind, and this could not with equal force be charged against him who had not read "The Wealth of Nations" or "The Origin of Species." Beyond the minimum of "Books that must be read," which we have ventured to suggest above, the reader may be left to rove at will among the treasures of our literature, applying such knowledge as we trust he has acquired in these studies.

Books that Need Not be Read. We have indicated above that we do not believe in any "best hundred books." A hundred books that have a universal appeal could not possibly be named by the most ingenious and omnivorous reader that ever attempted the task. At least forty of Lord Avebury's hundred might be left unread, and there are not more than ten books of Lord Acton's hundred that anyone but a leisured and polyglot monk need trouble to open. We have already named many books which need not be read, and, what is more to the purpose, we have agreed upon certain methods of testing a book which should enable each of us for himself to decide what not to read. Few books are so bad as not to generate one new thought in the mind of the reader; but so long as we can turn in a moment to any work which the verdict of time has placed among the great books of the world, we must not palter with the "unplaced" modern writer, unless we have for ourselves discovered that he has something to tell us for which we are the better, or which we want to know. Above all, while we have tastes in certain directions, let us develop these. Thus, if we delight in history, do not let us waste one moment with Maine's "Ancient Law" merely because Lord Acton thought that one of the hundred best books. Let us get through with Gibbon—a glorious task—although Lord Acton found no place for "The Decline and Fall" in his amazing list. Finally, in history and science no book need be read whose author is known to be untrustworthy; in philosophy none that has not been accepted by the mass of thinkers; in religion, none whose author has not been noted for sincerity, and who could not have said with Whitman:

> "Camerado, this is no book,
> Who touches this touches a man;"

in biography, no book that is not the work of a writer noted for his care no less than his sympathy and literary grace; in poetry, none that has not touched the heart of a generation, or awakened the enthusiasm of the most cultured; in fiction, nothing that is not in the estimation of honest criticism informed with real character, fidelity to life, and charm of style, no matter how widely it may have been sold or is selling. All such excluded, there will still remain a sufficient number of great and enduring works of literature to occupy the most insatiable reader throughout a fairly long life!

Literature concluded

ITALIAN—FRENCH—GERMAN—SPANISH

Italian by F. de Feo; French by L. A. Barbé, B.A.; German by P. G. Konody and Dr. Osten; Spanish by A. de Alberti and H. S. Duncan

ITALIAN

Continued from page 3643

By Francesco de Feo

PERSONAL PRONOUNS—continued

Conjunctive Forms. The forms *me, a me, te, a te, noi, a noi*, etc., are used when emphasis is laid on the pronouns; but when the pronoun is of secondary importance in the sentence, which is nearly always the case, the following forms must be used:

mi	for *me, a me*, me, to me
ti	„ *te, a te*, thee, to thee
ci	„ *noi, a noi*, us, to us
vi	„ *voi, a voi*, you, to you
si	„ *sè, a sè*, himself, to himself, etc.
gli	„ *a lui, a esso*, to him (to it)
le	„ *a lei, a essa*, to her (to it)
loro	„ *a loro*, to them
lo	„ *lui, esso*, him (it)
la	„ *lei, essa*, her (it)
li	„ *loro, essi*, them
le	„ *loro, esse*, them

The student should here observe the forms: *ne* (some, any) = of him, of it, from it, etc. *ci, vi* (there) = in it, in them, etc.

NOTE. The forms *mi, ti, vi, lo, la* may be written *m', t', v' l', l'* before any vowel; *ci* may be written *c'* only before *e* and *i*. The above forms of pronoun are, as a rule, placed before the verb, except *loro*, which is generally placed after it. In compound tenses they precede the auxiliary, and in negative sentences they are placed between the negative and the verb. Exceptions to this rule will be given below.

Examples:

1. *Io ti vedo*, I see thee.
2. *Io ti parlo*, I speak to thee.
3. *V'inviterò*, I shall invite you.
4. *Vi darò*, I will give (to) you.
5. *Ci mostràrono*, they showed (to) us.
6. *C' è, non c' è*, there is, there is not.
7. *Ne ho gran rispetto*, I have a great respect for him.
8. *L' avete comprato?* Have you bought it?
9. *Li avete venduti?* Have you sold them?
10. *Non le abbiamo vedute*, We have not seen them.
11. *Ho parlato loro*, I have spoken to them.
12. *Gli ho parlato*, I have spoken to him.

NOTE. *Gli* may be used also for *loro*: *Gli hanno dato un buon esèmpio*, They have set him (or them) a good example.

Observe from the above examples (8, 9, 10) that the past participle agrees with the object when the object is placed before the verb. A past participle that precedes the object is invariable. Example: *Avete spedito le lettere? Sì, le ho spedite.*

EXERCISE XXV.

1. Li incontreremo. 2. Ci daranno. 3. Gli mandàrono. 4. Che cosa (*what*) vi ha detto? 5. Che cosa gli avete risposto? 6. Dove sono i fiori che abbiamo raccolti? 7. Li ho messi nell'acqua. 8. Appena (*as soon as*) lo vedrò, gli parlerò di te. 9. L'ho veduto dalla finestra e l'ho chiamato ad alta voce due volte, ma non mi ha sentito. 10. La Maria ci disse che sarebbe andata in Italia quest'anno. 11. Essi hanno comprato un mùcchio di libri; li hanno letti e riletti, ma son sicuro che non ne hanno capito niente.

EXERCISE XXVI.

1. Quanto (*how much*) avete pagato codesti guanti? 2. Li ho pagati un po' caro, ma sono di una qualità eccellente. 3. Li avete trovati in casa? 4. Lei sì, ma non lui. 5. Quando mi darete quello che m'avete tante volte promesso? 6. Se mi date dei giocàttoli io sarò buono. 7. Avete più carta da lèttere? Voglio (*I wish*) scrivere al mio libraio che mi mandi i libri che gli ho ordinati. 8. Mi dispiace (*I am sorry*), non ne ho più; vi ho dato tutta la carta che mi restava. 9. Non fa niente, gli scriverò più tardi.

VERBS—continued

Second Conjugation. Infinitive in *ēre* (long) or *ĕre* (short). Examples: *temère*, to fear; *crèdere*, to believe. We shall here give the full conjugation of the verb *crèdere* only, as a model for the verbs of the second conjugation, since the only difference consists in the length of the infinitive. This difference, however, is very important, and care should be taken to distinguish whether the accent falls on the *penultimate* (on the termination) or on the *antepenultimate* (on the stem). Those who know Latin will notice that some verbs have displaced their accent in passing from one language into the other. Example: Latin *cadĕre*, Italian *cadére* (to fall). We shall here always indicate where the accent falls.

Crèdere, to believe

INDICATIVE MOOD

Present

I believe, etc.	We believe, etc.
credo	*crediamo*
credi	*credete*
crede	*crèdono*

Past Indefinite

I have believed, etc.	We have believed, etc.
ho creduto	*abbiamo creduto*
hai creduto	*avete creduto*
ha creduto	*hanno creduto*

Imperfect

I believed, etc.	We believed, etc.
credevo	*credevamo*
credevi	*credevate*
credeva	*credèvano*

First Pluperfect

I had believed, etc.	We had believed, etc.
avevo creduto	*avevamo creduto*
avevi creduto	*avevate creduto*
aveva creduto	*avévano creduto*

Past Definite

I believed, etc.	We believed, etc.
credèi, -etti	*credemmo*
credesti	*credeste*
credè, -ette	*credèrono, -èttero*

Second Pluperfect

I had believed, etc.	We had believed, etc.
ebbi creduto	*avemmo creduto*
avesti creduto	*aveste creduto*
ebbe creduto	*èbbero creduto*

Future

I shall believe, etc.	We shall believe, etc.
crederò	*crederemo*
crederai	*crederete*
crederá	*crederanno*

Future Perfect

I shall have believed, etc.	We shall have believed, etc.
avrò creduto	*avremo creduto*
avrai creduto	*avrete creduto*
avrà creduto	*avranno creduto*

IMPERATIVE MOOD

Present

Believe, etc.	Let us believe, etc.
—	*crediamo*
credi	*credete*
creda	*crèdano*

SUBJUNCTIVE MOOD

Present

That I believe, etc.	That we believe, etc.
creda	*crediamo*
creda	*crediate*
creda	*crèdano*

Perfect

That I have believed, etc.	That we have believed, etc.
àbbia creduto	*abbiamo creduto*
àbbia creduto	*abbiate creduto*
àbbia creduto	*àbbiano creduto.*

Imperfect

If I believed, etc.	If we believed, etc.
credessi	*credèssimo*
credessi	*credeste*
credesse	*credèssero*

Pluperfect

If I had believed, etc.	If we had believed, etc.
avessi creduto	*avèssimo creduto*
avessi creduto	*aveste creduto*
avesse creduto	*avèssero creduto*

CONDITIONAL MOOD

Present

I should believe, etc.	We should believe, etc.
crederei	*crederemmo*
crederesti	*credereste*
crederebbe	*crederèbbero*

Perfect

I should have believed, etc.	We should have believed, etc.
avrei creduto	*avremmo creduto*
avresti creduto	*avreste creduto*
avrebbe creduto	*avrèbbero creduto*

INFINITIVE MOOD

Present

crèdere, to believe.

Perfect

avèr creduto, to have believed.

Gerund

Present—credendo, believing
Perfect—avendo creduto, having believed

Participle

Present—credente, -i, believing
Perfect—creduto, -a, -i, -e, believed

EXERCISE XXVII.

1. Riceveremo. 2. Avete bevuto? 3. Se noi perdèssimo. 4. Temèvano. 5. Non avrèbbero creduto. 6. Avreste venduto? 7. Venderemmo. 8. Vendemmo. 9. Ha (egli) ricevuto? 10. Io non ho ancora ricevuto, ma riceverò. 11. Egli è sempre senza danaro, eppure ne riceve sempre. 12. Quanto credete che egli àbbia ricevuto ultimamente? 13. Ricevette cinquanta lire la settimana scorsa, ma ne riceverà altrettante domani. 14. Vendemmo il nostro giardino e venderemo pure la casa. 15. Non posso crèdere ch'egli non àbbia ricevuto il nostro invito. 16. Andiamo, se no perderemo il nostro tempo inutilmente. 17. Se non stiamo attenti, ho paura che perderemo quello che (what) abbiamo già guadagnato. 18. Le foglie incomìnciano a cadère. 19. Quei valorosi combattèrono tutti fino alla morte.

Third Conjugation. Infinitive in *-ire.* The verbs of the third conjugation may be divided into three classes:

1. Verbs in which the terminations are added directly to the stem in all tenses, as: *vestire,* to dress; *partire,* to start. [See page 3210.] The verbs belonging to this class are very few.

2. Verbs which, in the singular and in the third person plural of the present of the indicative, imperative, and subjunctive, insert the syllable *isc* between the stem and the terminations, as: *capire,* to understand; present indicative, *cap-isc-o.*

3. Verbs which can be conjugated either with or without the addition of the syllable *isc,* as: *nutrire,* to feed; present indicative, *nutro* and *nutrisco.*

Vestire, to dress

Indicative Mood

Present

I dress, etc.	We dress, etc.
vesto	*vestiamo*
vesti	*vestite*
veste	*vèstono*

Past Indefinite

I have dressed, etc.	We have dressed, etc.
ho vestito	*abbiamo vestito*
hai vestito	*avete vestito*
ha vestito	*hanno vestito*

Imperfect

I dressed, etc.	We dressed, etc.
vestivo	*vestivamo*
vestivi	*vestivate*
vestiva	*vestìvano*

First Pluperfect

I had dressed, etc.	We had dressed, etc.
avevo vestito	*avevamo vestito*
avevi vestito	*avevate vestito*
aveva vestito	*avèvano vestito*

Past Definite

I dressed, etc.	We dressed, etc.
vestii	*vestimmo*
vestisti	*vestiste*
vestì	*vestìrono*

Second Pluperfect

I had dressed, etc.	We had dressed, etc.
ebbi vestito	*avemmo vestito*
avesti vestito	*aveste vestito*
ebbe vestito	*èbbero vestito*

Future

I shall dress, etc.	We shall dress, etc.
vestirò	*vestiremo*
vestirai	*vestirete*
vestirà	*vestiranno*

Future Perfect

I shall have dressed, etc.	We shall have dressed, etc.
avrò vestito	*avremo vestito*
avrai vestito	*avrete vestito*
avrà vestito	*avranno vestito*

Imperative Mood

Present

Dress, etc.	Let us dress, e
—	*vestiamo*
vesti	*vestite*
vesta	*vèstano*

Subjunctive Mood

Present

That I dress, etc.	That we dress, etc.
vesta	*vestiamo*
vesta	*vestiate*
vesta	*vèstano*

Perfect

That I have dressed, etc.	That we have dressed, etc.
àbbia vestito	*abbiamo vestito*
àbbia vestito	*abbiate vestito*
àbbia vestito	*àbbiano vestito*

Imperfect

If I dressed, etc.	If we dressed, etc.
vestissi	*vestìssimo*
vestissi	*vestiste*
vestisse	*vestìssero*

Pluperfect

If I had dressed, etc.	If we had dressed, etc.
avessi vestito	*avèssimo vestito*
avessi vestito	*aveste vestito*
avesse vestito	*avèssero vestito*

Conditional Mood

Present

I should dress, etc.	We should dress, etc.
vestirei	*vestiremmo*
vestiresti	*vestireste*
vestirebbe	*vestirèbbero*

Perfect

I should have dressed, etc.	We should have dressed, etc.
avrei vestito	*avremmo vestito*
avresti vestito	*avreste vestito*
avrebbe vestito	*avrèbbero vestito*

Infinitive Mood

Present

vestire, to dress

Perfect

avèr vestito, to have dressed

Gerund

Present—*vestendo*, dressing
Perfect—*avendo vestito*, having dressed

Participle

Present—*vestente*, *-i*, dressing
Perfect—*vestito*, *-a*, *-i*, *-e*, dressed

Exercise XXVIII.

1. Partiremo. 2. Se fòssimo partiti. 3. Non aprite. 4. Sentite. 5. Se avèssero seguito. 6. Soffrirèbbero. 7. Quella pòvera donna soffrì tanto quando il figliuolo partì. 8. Se i bottegai ci servìssero male avremmo ragione di andare a spèndere altrove. 9. Aprite la finestra, fa troppo caldo. 10. Partirei domani se avessi finito i miei affari. 11. Questi fanciulli dòrmono troppo. 12. Appena videro il perìcolo fuggìrono tutti e lo lasciàrono solo. 13. Quante volte li abbiamo uditi dire che erano stanchi di studiare! 14. Venite con me. 15. Fuggite la compagnìa dei cattivi, e seguite l'esèmpio dei buoni.

Key to Exercise XXIII.

1. We have worked more than you. 2. The letter has been written by me and not by him. 3. If you accompany me, I will accompany you. 4. They always think quite the contrary of what they say. 5. They think they are behaving well, and instead they are behaving very ill. 6. We never have anything; they keep all for themselves. 7. She is very kind, but not he. 8. When we have been in need, they have always done much for us. 9. Thou thinkest always of thyself, and never thinkest of others. 10. A gentleman has asked for you.

Key to Exercise XXIV.

1. Dove andate? Se aspettate ancòra un poco verrò con voi. 2. Siete venuto in tempo noi parlavamo appunto di voi. 3. Credevamo che fosse lui, non lei. 4. Bisognerebbe imparare a far tutto da sè. 5. Abbiamo scritto sì a lui che a lei diverse volte, ma essi non hanno mai risposto alle nostre lèttere. 6. Chi ha rotto quel vaso? 7. Io no, è cascato da sè. 8. A chi avete consegnato il pacco, a lui o a lei? 9. A nessuno dei due, perchè essi non èrano in casa. 10. Non so capire perchè àbbia fatto a me una tale proposta.

Continued

FRENCH

Continued from page 3645

By Louis A. Barbé, B.A.

VERBS—continued

Finir, to finish

Second Conjugation. PRINCIPAL PARTS: *Finir, finissant, fini, je finis, je finis.*

INDICATIVE

SIMPLE TENSES	COMPOUND TENSES
Present	*Past Indefinite*
I finish, am finishing, etc.	I have finished, etc.
je finis	*j'ai fini*
tu finis	*tu as fini*
il, elle finit	*il, elle a fini*
nous finissons	*nous avons fini*
vous finissez	*vous avez fini*
ils, elles finissent	*ils, elles ont fini*
Imperfect	*Pluperfect*
I was finishing, used to finish, etc.	I had finished, etc.
je finissais	*j'avais fini*
tu finissais	*tu avais fini*
il, elle finissait	*il, elle avait fini*
nous finissions	*nous avions fini*
vous finissiez	*vous aviez fini*
ils, elles finissaient	*ils, elles avaient fini*
Past Definite	*Past Anterior*
I finished, etc.	I had finished, etc.
je finis	*j'eus fini*
tu finis	*tu eus fini*
il, elle finit	*il, elle eut fini*
nous finîmes	*nous eûmes fini.*
vous finîtes	*vous eûtes fini*
ils, elles finirent	*ils, elles eurent fini*
Future	*Future Anterior*
I shall finish, etc.	I shall have finished, etc.
je finirai	*j'aurai fini*
tu finiras	*tu auras fini*
il, elle finira	*il, elle aura fini*
nous finirons	*nous aurons fini*
vous finirez	*vous aurez fini*
ils, elles finiront	*ils, elles auront fini*

CONDITIONAL

Present	*Past*
I would finish, etc.	I would have finished, etc.
je finirais	*j'aurais fini*
tu finirais	*tu aurais fini*
il, elle finirait	*il, elle aurait fini*
nous finirions	*nous aurions fini*
vous finiriez	*vous auriez fini*
ils, elles finiraient	*ils, elles auraient fini*

IMPERATIVE

Present

finis, finish (thou)
qu'il finisse, let him finish
qu'elle finisse, let her finish
finissons, let us finish
finissez, finish (ye)
qu'ils finissent, let them (m.) finish
qu'elles finissent, let them (f.) finish

SUBJUNCTIVE

Present	*Past*
That I may finish, etc.	That I may have finished, etc.
que je finisse	*que j'aie fini*
que tu finisses	*que tu aies fini*
qu'il, qu'elle finisse	*qu'il, qu'elle ait fini*
que nous finissions	*que nous ayons fini*
que vous finissiez	*que vous ayez fini*
qu'ils, qu'elles finissent	*qu'ils, qu'elles aient fini*
Imperfect	*Pluperfect*
That I might finish, etc.	That I might have finished, etc.
que je finisse	*que j'eusse fini*
que tu finisses	*que tu eusses fini*
qu'il, qu'elle finît	*qu'il, qu'elle eût fini*
que nous finissions	*que nous eussions fini*
que vous finissiez	*que vous eussiez fini*
qu'ils, qu'elles finissent	*qu'ils, qu'elles eussent fini*

INFINITIVE

Present

finir, to finish

Past

avoir fini, to have finished

PARTICIPLE

Present

finissant, finishing

Past

fini, -e, finished
ayant fini, having finished

REMARKS. The negative, the interrogative, and the negative-interrogative forms being the same for all conjugations, it is not necessary to repeat them.

It is to be noted that all regular verbs of the second conjugation have the additional syllable *iss* in the present participle and in all the parts formed from it.

The verb *bénir*, to bless, has two forms of the past participle: *béni, bénie* and *bénit, bénite.* The latter of these is applied exclusively to that which is blessed or consecrated by a religious ceremony.

The verb *fleurir*, to blossom and to flourish, has two forms of the present participle, and of the imperfect indicative, which is formed from it: *fleurissant*, *fleurissais* and *florissant*, *florissais*. The second of these forms is used exclusively in the sense of to flourish, meaning to be prosperous.

The verb *haïr*, to hate, drops the diæresis in the three persons singular of the present indicative: *je hais*, *tu hais*, *il hait*; and in the second person singular of the imperative: *hais*. It is the only verb that does not take a circumflex accent in the first and second persons plural of the past definite and the third singular of the imperfect subjunctive: *nous haïmes*, *vous haïtes*, *qu'il haït*

EXERCISE XXVI.

1. When I was a child I was very bashful (*honteux*); I used to blush (*rougir*) up to the (*jusqu'aux*) eyes when anyone spoke to me.
2. The earth is never ungrateful (*ingrat*); it feeds (*nourrir*) with (*de*) its fruits all those who cultivate it.
3. It is not age, it is grief (*le chagrin*) that has made his hair white (*blanchir*).
4. If you do not choose (*choisir*) a good spot (*un endroit*) to lay (*établir*) the foundation (*les fondations*) of the house, you will be obliged to pull it down (*démolir*).
5. The shame of that action reflects (*réfléchir*) on all those who have participated (*participer à*) in it.
6. Amongst the trees, almond-trees (*amandier*) blossom (the) first, and medlars (*néflier*) last.
7. After so many calamities (*calamité*) it is astonishing (*étonnant*) that this country should be (pres. subj.) so flourishing to-day.
8. The arms which have been blessed by (*par*) the Church are not always blessed by (*de*) heaven on the battlefield.
9. There are men by (of) whom it is glorious to be hated.
10. We (one) do not always hate those whom we render unhappy.
11. Good books cure (*guérir*) the diseases (*la maladie*) of the mind (*esprit*, m.).
12. A free (*libre*) people (*peuple*) obeys (*obéir*), but it does not serve (*sert*).

KEY TO EXERCISE XXV.

1. Plus il avançait en âge, plus il avançait en sagesse.
2. La manière dont les Romains prononçaient le latin était très différente de celle dont nous le prononçons aujourd'hui.
3. Il partagea sa fortune entre ses trois enfants.
4. Selon un proverbe français, l'appétit vient en mangeant.
5. Il appelle sur son bienfaiteur les bénédictions du ciel.
6. On dit d'un homme qui dissipe sa fortune, qu'il jette son argent par la fenêtre.
7. Cette lettre nous annonce une bonne nouvelle.
8. La leçon commence à la page soixante-dix.
9. Envoyez cette pendule chez l'horloger pour qu'il l'arrange.
10. Je gagerais volontiers cent francs que ce n'est pas lui qui remportera le prix.
11. En mil six cent soixante, Charles II. fut rappelé au trône.
12. Ce poisson est trop petit; rejetez-le dans l'eau.
13. Quand les pêcheurs seront en pleine mer, ils jetteront leurs filets.
14. Ceux qui emploient mal leur temps sont les premiers à se plaindre de sa brièveté.
15. La lumière emploie de sept à huit minutes à nous venir du soleil.
16. Nous pardonnons souvent à ceux qui nous ennuient; mais nous pardonnons rarement à ceux que nous ennuyons.
17. Nous avons acheté la victoire au prix de nos meilleurs soldats.
18. Ce qu'on achète en détail est plus cher que ce qu'on achète en gros.
19. Il a gelé toute la nuit; s'il gèle encore demain, nous pourrons peut-être patiner samedi.
20. Dieu a tiré le ciel et la terre du néant; il les a créés par sa parole.
21. Agréez, Monsieur, mes salutations respectueuses—formule qu'on emploie souvent en terminant une lettre.
22. On est quelquefois obligé de céder aux circonstances.
23. Ce n'est pas lui qui possède sa fortune, c'est sa fortune qui le possède.
24. Tout chemin mène à Rome, dit le proverbe.

Continued

GERMAN

By P. G. Konody and Dr. Osten

VERBS—continued

LXXVI. Copulative Verbs. The verbs sein, werden, bleiben (to remain), heißen (to call, name), scheinen (to seem, appear), dünken (to seem, appear) form the connecting link between two nominatives—that of the subject, and that of the complement: Er (nominative) ist, wird, bleibt, scheint, dünkt (mir) ein Betrüger (nominative), he is, is getting, remains, seems (to be) a cheat.

LXXVII. As in the case of the copulative verbs several verbs may be connected with two accusatives, that of the object and that of the noun in apposition with it. Such verbs are: heißen, to call; rühmen, preisen, to praise; schelten, to scold; schimpfen, to abuse; taufen, to name; nennen, to name. Man hieß ihn (accusative) einen Helden (accusative), They called him a hero; er nannte ihn einen Verläumder, He called him a slanderer. Rühmen and preisen are often used with the conjunction als (in the capacity of): Der Direktor rühmte, pries ihn (accusative) als (conjunction) einen verläßlichen Beamten (accusative), The director praised him as a reliable employee. When brought into the passive voice, the two accusatives are changed into nominatives: Er (nominative) wurde ein

Held (nominative) geheißen; er wurde ein Verläumder genannt; er wurde vom Direktor als ein verläßlicher Beamter gerühmt.

LXXVIII. Verbs Governing the Accusative and Infinitive: sehen, to see; hören, to hear; fühlen, to feel; finden, to find; lehren, to teach; lassen, to let; machen, to make; heißen, to command, etc. Ich sah ihn (accusative) fallen (infinitive), I saw him fall; Ich hörte das Mädchen singen, I heard the girl sing; Ich fühlte mein Herz klopfen, I felt my heart beat; Ich fand ihn gut aussehen, I found him looking well, etc. If the dependent infinitive is a copulative verb, the two obligatory nominatives [see LXXVI.] are changed into accusatives. Thus, if lassen stands with the infinitive of the copulative verb sein, the subject of the latter and the following noun are changed into the accusative: Er läßt den Zufall (accusative) seinen Führer (accusative) sein, He lets chance be his guide. Sentences with a proper object in the accusative (that is to say with transitive verbs) naturally have two accusatives—one of the object dependent on the governing transitive verb, and one of the object dependent on the infinitive. The sentence: Ich sah, wie der Vogel (subject nominative) seine Flügel (object accusative) ausbreitete, I saw how the bird spread his wings, is changed into: Ich sah den Vogel (accusative) seine Flügel (accusative) ausbreiten (infinitive), I saw the bird spread its wings. Ich hörte, wie der Künstler ein Lied sang, I heard how the artist sang a song; and: Ich hörte den Künstler ein Lied singen, I heard the artist sing a song.

LXXIX. Displacement of the Verb in Independent Sentences. If an independent sentence is introduced by an adverb or an adverbial noun, the verb has to precede the subject, and has to occupy the same position as in the independent question: Ich bin hier (adverb of place), and: Hier bin ich. Es gibt keine Wirkung ohne Ursache, There is no effect without cause, and: Ohne Ursache gibt es keine Wirkung.

LXXX. Verbs with Accusative and Genitive. Many verbs with an "object of the person" (transitives and reflectives) require a complement "of matter" in the genitive. Example: entheben, to exempt from, to dismiss from; Er enthob ihn (personal object) seiner Verpflichtung (genitive), He released him from his obligation. Verbs requiring such complementary genitives are: anklagen, beschuldigen, bezichtigen, zeihen, to accuse; überführen, to convict; entbinden, entledigen, to release from, to deliver; entkleiden, to divest; erinnern, to remind; frei'sprechen, to acquit; versichern, to assure, etc.: Die Geschworenen sprachen den An'geklagte (accusative) des Verbrechens (genitive) frei, The jury acquitted the defendant [of the crime]; Der An'kläger beschuldigte ihn (accusative) der schrecklichen Tat (genitive), The prosecutor accused him of the monstrous deed; Ich entbinde dich deines Versprechens, I release you from your promise.

The following reflective verbs require also the genitive of matter with the accusative of the person: (sich einer Sache) annehmen, to interest oneself in . . .; bedienen, to help oneself; bemächtigen, to seize; entsinnen, to remember; freuen, to rejoice in; rühmen, to glory in; schämen, to be ashamed of; erbarmen, to take pity on, etc.: Ich nahm mich (accusative) seiner (genitive) an (separable prefix), I took interest in him; Du bedientest dich meines Einflusses, You made use of my influence; Der Feind bemächtigte sich der Festung, The enemy seized the fortress; Wir entsinnen uns des Fremden, We remember the stranger; Ihr freut euch des Lebens, You rejoice in life; sie rühmen sich ihrer Tat, They glory in their deed.

LXXXI. Interjections. These words are outside the syntactic structure of the sentence, and therefore do not generally govern other nouns, though they may require dependent cases or certain prepositions, such as auf, über (on): Pfui über (4) dich! Shame on you! Schande auf (4) ihn! Disgrace on him! Dependent clauses can also be added to interjections: Pfui, schäme dich, daß du so unwahr bist! Fie! Be ashamed to be so untruthful!

LXXXII. Omission and Displacement of the Auxiliary Verb. To achieve increased vivacity and force, the finite auxiliary verb may sometimes be dropped from the end of a subordinate clause: Wir bestiegen, nachdem wir das Haus verlassen [hatten], den Wagen, We got into the carriage after having left the house; Der Richter fiel ihm, bevor er geendet [hatte], ins Wort, The judge interrupted him before he had finished.

1. Omissions of finite auxiliary verbs occur frequently for the sake of euphony, to avoid the clashing of forms sounded alike: Der Brief, der gestern früh abgegangen [ist], ist erst heute Abends eingelangt, The letter which was despatched yesterday morning, has only arrived to-night; der Mann, der es euch gesagt [hat], hat sich mit euch einen Scherz gemacht, The man who told you of it has made fun of you.

2. The displacement of the auxiliary verb werden occurs when the same forms would follow each other directly: for instance, in: Ich hoffe, daß der junge Mann und das Mädchen ein glückliches Paar werden werden, I hope that the young man and the girl will become a happy couple; one of the two „werden" must be displaced, so that the sentence would read: Ich hoffe, daß der junge Mann und das Mädchen werden ein glückliches Paar werden. Sometimes an adverb is repeated for similar reasons: Sobald die Früchte reif werden werden, werden wir sie abnehmen, As soon as the fruit becomes ripe, we shall gather it, is changed into: Sobald die Früchte werden reif werden, sobald (repeated) werden wir sie abnehmen.

LXXXIII. Elliptic Sentences. Force, vivacity, and conciseness are sometimes brought about in German by the omission of the predicate, if the meaning of the curtailed sentence is not impaired by this proceeding, or if the missing words can easily be understood: [Sei] Willkommen! Be welcome! Woher [kommt Ihr] des Weges? Whence do you come? Keine Rose [gibt es or ist] ohne Dornen, There is no rose without thorns. This elliptic form frequently occurs in proverbs and proverbial sayings.

LXXXIV. Tenses in Dependent Clauses. In German the rules which govern the tenses in principal sentences and dependent clauses are not very strict. If the principal sentence contains a verb in the present, perfect, or future, any of the six tenses may at times be employed in the dependent clause. But it is safest to make the tense of the dependent clause agree with that of the principal sentence, especially if the verb of the dependent clause is in the subjunctive mood.

EXAMINATION PAPER XX.

1. What are copulative verbs, and which verbs belong to this group?
2. If the complement used with a copulative verb is a substantive, in what case must it stand?
3. What verbs are used with two accusatives, and into which case are these accusatives changed, if the sentence is transposed into the passive voice?
4. Which verbs govern the accusative with the infinitive?
5. What is the result, if this infinitive is a copulative verb?
6. How many accusatives are under these circumstances used with the transitive verb?
7. In what manner are the words displaced if an independent sentence is introduced by an adverb or an adverbial noun?
8. Which verbs require a complementary genitive with the object of the person?
9. Which prepositions are required by certain interjections?
10. For what reason are the finite verbs sometimes omitted, and which class of verb can thus be dropped?
11. When is it necessary to displace an auxiliary verb, and which auxiliary verb is subject to this displacement?
12. What omissions occur in elliptic sentences, and when is such a curtailment admissible?
13. Is it necessary to make the tense of the dependent clause agree with that of the principal sentence?
14. Under what circumstances is it preferable to make them agree?

CONVERSATIONAL EXERCISES

III. In the Street

Which is my best way to King Street?	Wie gehe ich am besten in die Königsstraße?
Straight on to the church, and then the fourth turning on the right.	Gerade bis zur Kirche, und dann die vierte Straße rechts.
Thank you very much.	Ich danke bestens, or, Besten Dank.
Would you kindly tell me where the cathedral is?	Können Sie mir gefälligst sagen, wo die Kathedrale ist?
At the end of the next turning on the left.	Am Ende der nächsten Straße links.
How far is it to the Zoological Gardens?	Wie weit ist es zum Zoologischen Garten?
Scarcely five minutes.	Kaum fünf Minuten.
Oh, it is very far from here.	O, es ist sehr weit von hier.
Is there any 'bus or tram going there?	Gibt es einen Stellwagen oder eine Pferdebahn dahin?
Oh yes, you can get there by 'bus.	O ja, Sie können mit dem Omnibus hinkommen.
Which is the High Street, please?	Bitte, welche ist die Hauptstraße?
The long street opposite the church.	Die lange Straße gegenüber der Kirche.
Would you kindly tell me where there is a tobacconist?	Könnten Sie mir gütigst sagen, wo hier ein Tabakladen ist?
How do I get to the Rome Hotel, please?	Wie komme ich zum Hotel Rom, bitte?
Round the corner, and then the second on the right.	Um die Ecke, und dann die zweite Straße rechts.
I want to go to the museum; which is the shortest way?	Ich will nach dem Museum; welches ist der kürzeste Weg?
Could you tell me the time?	Könnten Sie mir sagen, wie spät (wie viel Uhr) es ist?
Half-past five.	Halb sechs Uhr.
May I trouble you for a light?	Darf ich Sie um Feuer bitten?

IV. In the Shop

Do you keep picture postcards?	Haben Sie Ansichtskarten?
Here, if you please.	Hier, bitte.
I want some with the museum, the church, the Royal Palace.	Ich möchte welche mit dem Museum, der Kirche, dem Königlichen Schlosse darauf.
How much is a dozen?	Was kostet das Dutzend?
One mark twenty pfennigs.	Eine Mark zwanzig Pfennige.
Here are ten marks. Will you, please, give me the change in one-mark pieces?	Hier sind zehn Mark. Geben Sie mir, bitte, den Rest in Markstücken.
I want a hat.	Ich brauche einen Hut.
Of what kind? A top hat, a felt hat, or one of straw?	Welcher Art? Einen Cylinder, einen Filzhut, oder einen aus Stroh?
A soft grey felt hat.	Einen weichen grauen Filzhut.
This one is too big for me.	Deiser ist mir zu groß.
Here is a smaller one. This one fits well.	Hier ist ein kleinerer. Dieser sitzt gut.
What is the price? Nine marks.	Was kostet er? Neun Mark.
Can you send it to me at the hotel?	Können Sie ihn mir ins Hotel schicken?
I'll put down the address.	Ich will die Adresse aufschreiben.

How much is the umbrella in your shop-window?	Was kostet der Regenschirm in Ihrem Auslagefenster?
Which one do you mean?	Welchen meinen Sie?
The black one with the silver handle.	Den schwarzen mit dem silbernen Griff.
Eighteen marks.	Achtzehn Mark.
That is too dear; haven't you got a cheaper one?	Das ist mir zu teuer; haben Sie nicht einen billigeren?
Oh yes, but not of such good silk.	O ja, aber nicht aus so feiner Seide.
I should like to change English money for German.	Ich möchte gerne englisches Geld gegen deutsches einwechseln.
Is it gold or paper?	Ist es Gold oder Papier?
I have some sovereigns and five-pound notes.	Ich habe einige Sovereigns und Fünf-Pfund-Noten.
How much of each?	Wie viel von jeder Sorte?
Ten pounds in gold and fifteen in notes.	Zehn Pfund in Gold und fünfzehn in Noten.
How many marks do you reckon to the pound?	Mit wie viel Mark berechnen Sie das Pfund?
Nineteen marks 75 pfennigs.	Mit 19 Mark 75 Pfennige.
Don't you want some small change as well?	Brauchen Sie nicht auch einiges Kleingeld?
Will you kindly change marks for English money?	Wollen Sie mir gefälligst Mark in englisches Geld umwechseln?
How much do you reckon a pound sterling?	Wie berechnen Sie das Pfund Sterling?
We charge 20 marks for one pound.	Wir berechnen 20 Mark für ein Pfund.
I have 420 marks, that would be £21.	Ich habe 420 Mark, das würde also £21 ausmachen.
Can I have £1 in silver?	Kann ich ein Pfund in Silber haben?
Do you want half-crowns, or shillings also?	Wünschen Sie halbe Kronen oder auch Schillinge?

Continued

SPANISH

Continued from page 3497

By Amalia de Alberti & H. S. Duncan

BEFORE proceeding further with the study of the verbs, it may be well to pause for one lesson the more thoroughly to comprehend certain important points which affect one's knowledge of what may be termed the living language of Spain; points which have perhaps not been sufficiently insisted upon in previous lessons. In all languages there is, of course, the literary and the commercial use of words, and while a student who has had his attention concentrated on one or other of these uses, but not equally on both, may truly have acquired a good working knowledge of the foreign tongue, he is in danger of lacking the readiness of application which comes from knowing the varying values of words and modes of composition. We have so far endeavoured chiefly to give in our vocabularies and our exercises such examples as might be considered of "literary" rather than "commercial" use, holding that the knowledge of any language for its own sake should always take precedence over its application to the uses of the market-place. But at this stage it is well that our consideration of Spanish should proceed with increasing regard to the work of, say, a Spanish merchant's office in one of our great cities, or clerical work in one of the Spanish-speaking countries of the old or new world. This also should be mentioned at this point: that in certain of the passages which we have transcribed from standard Spanish authors, words occasionally, though rarely, occur which in more recent years have become somewhat archaic, just as in English speech words are constantly undergoing modification. It should also be noted that the Spanish authors of the past, though the most entertaining and instructive to read, not only make use of certain archaic words, but also of phrases, which, while the student should be familiar with them, are not to be reproduced by him in writing the language. He must avoid such forms as

Destas for *de estas*
Dellos ,, *de ellos*, etc.

All such cases, so far as our readings in this course are affected, are covered by the words and phrases in the following brief vocabulary:

Vocabulary	Vocabulario
The grandfather	El abuelo
The grandmother	La abuela
A share	Una accion
The farmer	El agricultor
Sea water	Agua de mar
The flag	La bandera
A trunk	Un baúl
The library	La bibliotéca
The country	El campo
A desk	Una carpeta
A surgeon	Un cirujano
A merchant	Un comerciante
Inasmuch as	Como quiera que
Destination	Destino
To contend	Disputar
An endorsement	Un endoso
A sculptor	Un escultor
The stars	Las estrellas
To exaggerate	Exagerar
Field flowers	Flores silvestres
A picklock	Una ganzúa
A gipsy	Un gitano
A guarantee	Una garantia
A throat	Una garganta
A sentry-box	Una garita
The gamekeeper	El guarda
Until	Hasta
Heliotrope	Heliotropo
A man of knowledge	Un hombre instruido
Incredible	Increible
A shawl	Un mantón

A doctor	Un médico
Foreign country	Pais extranjero
Picturesque	Pintoresco
A porthole	Una portilla de luz
The cousin	El primo (*fem.*, la prima)
The sunset	La puesta del sol
The hand-bag	El saco de mano
A joint-stock company	Una sociedad en comandita
A slash	Un tajo
The grocer	El especiero
Draper's shop	Tienda ó almacen de tejidos
The uncle	El tio
The aunt	La tia
Wholesale	La venta al por mayor

MISCELLANEOUS PHRASES	FRASES SUELTAS
Let us count our money	Contémos nuestro dinero
To go to the confectioner's to eat pastry, take ices, and drink lemonade	Ir á la confiteria para comer pasteles, tomar helados, y beber limonada
We were fortunate to obtain a private audience of the Pope	Fuimos afortunados en obtener una audiencia privada del Papa
I am glad to come home	Me alegro de volver á casa
The bookkeeper is making up the accounts for the end of the year	El tenedor de libros está haciendo las cuentas de fin de año
This gentleman has a letter of credit upon our house	Este caballero tiene una carta de crédito contra nuestra casa

Importance of Accents. Insignificant as these may appear to a beginner they are really of vital importance, as the omission or misuse of them may entirely alter the tense or person of a verb, confuse verbs with substantives, and one substantive with another.

EXAMPLES. *Yo amo*, I love; *él amó*, he loved; *el amo*, the master or owner.

Yo hablé, I spoke; *hable Vd*, speak you; *que yo hable* (subj.), that I may speak (imp.); or, let me speak.

El Papa, the Pope; *el papá*, the father.

These examples might be multiplied indefinitely; but they will suffice to demonstrate the importance of thoroughly mastering the use and position of the accent.

Article, Gender and Number. For the present purpose these three may be considered together in their relation to one another. Special care must be taken to make the articles and adjectives agree in gender and number with the substantives and pronouns to which they relate. Verbs must also agree with these as regards number, and likewise in gender, where the past participle is employed adjectively. The rules already given should be carefully studied.

EXAMPLES. *El Emperador Nerón fué cruelísimo*, The Emperor Nero was most cruel.

Esa muchacha es amabilísima, That girl is most amiable.

Tengo una hermosa biblioteca y algunos libros espléndidos, I have a beautiful library and some splendid books.

El mar está placido, The sea is calm.

Las señoras están sentadas en el salon, The ladies are seated in the drawing-room.

La moral de las naciones difiere, The morals of nations differ.

Las casas que tengo compradas no me gustan, The houses which I have bought do not please me.

It might be noted here that a number of words change their meaning entirely according to the gender of the article employed.

EXAMPLES. *El capital* (capital, money); *la capital* (capital of a country); *el corte* (cut); *la corte* (the Court); *el órden* (order, sequence); *la órden* (order, command, mandate); *el papá*, the father; *la papa*, the potato.

Dates, Days, Months. The first of a month is variously called *el primero del mes*, *el primer dia* or *el dia primero*.

Note that the final *o* in *primero* and *tercero* is dropped when used before a masculine noun.

The days are written with a small letter and, like the dates of the month, are preceded by the article *el*. The months are spelt with a capital: *El domingo, el 11 de Septiembre, el mes de Agosto.*

Euphony. This is also a very important point in speaking and writing Spanish elegantly, but fortunately the rule is easily acquired.

Before words beginning with *i* or the unaspirated *h* followed by *i*, be careful to use *é* for "and" instead of the usual *y* (*ee-griega*). Similarly, before words beginning with *o* it is usual to use *ú* for "or" thus:

Ese hombre es cobarde é ingrato, That man is cowardly and ungrateful.

Los caballeros é hidalgos, Gentlemen and noblemen.

Salvo error ú omision, Errors and omissions excepted.

Feminine words beginning with *a* on which the stress falls take the masculine article:

El alma, the soul; *el agua*, the water; *el ama*, the mistress.

Errata. We take this opportunity of printing the following important corrections of a series of errors which unfortunately we were unable to correct in all the copies containing page 2917.

PERSONAL PRONOUNS (Accusative)

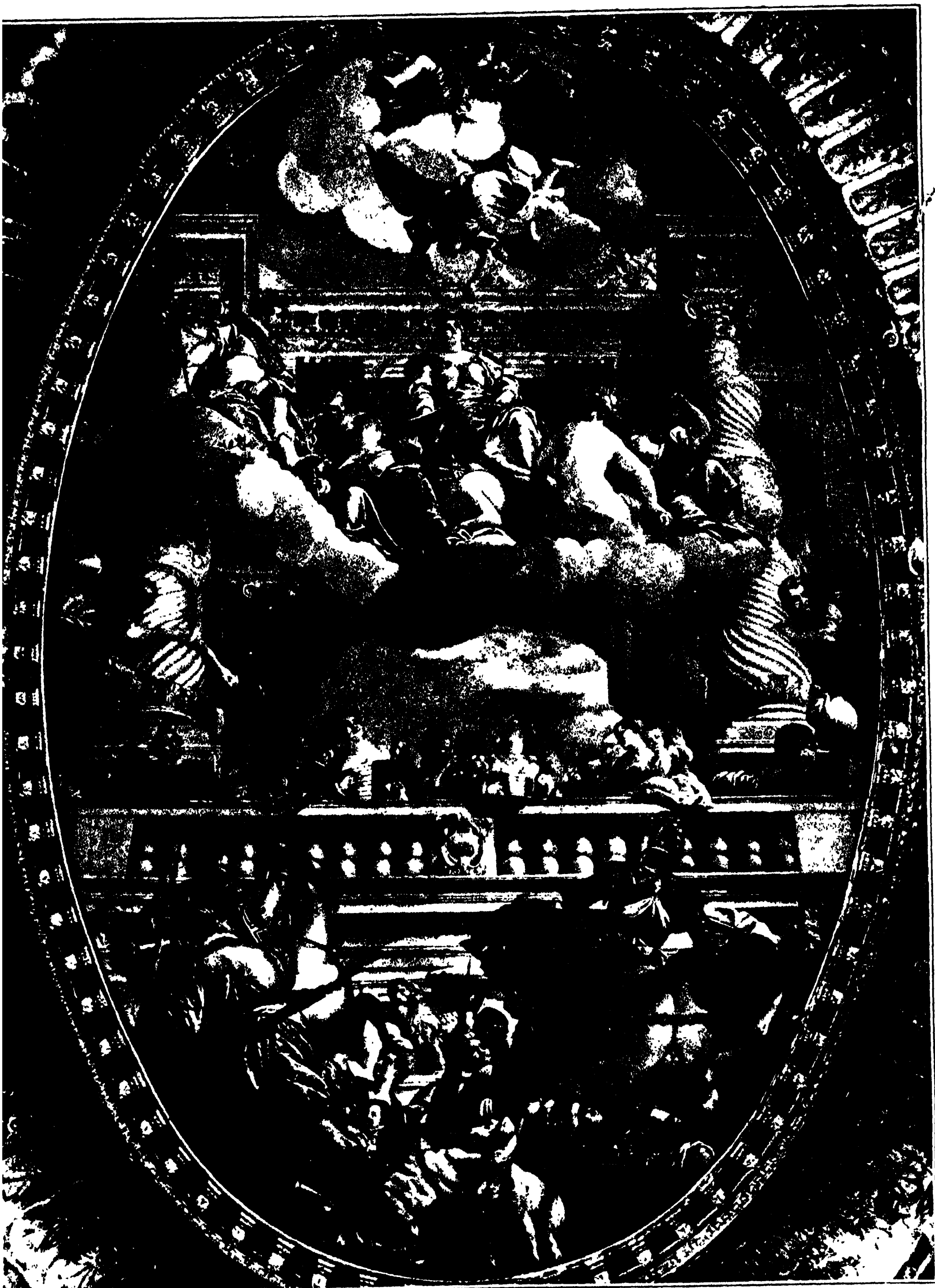
Le quiero, I like him
La quiero, I like her
Les quiero, I like them
Las quiero, I like them (f.)

PERSONAL PRONOUNS (Dative)

Le hablé, I spoke to him *or* her
Le dí, I gave him, *or* to him *or* her
Le compré, I bought him, *or* for him *or* her
Le quité, I took from him, *or* her
Les envié, I sent them, *or* to them, *or* to you
Le hablé á él, I spoke to him
Le hablé á ella, I spoke to her
Me dijo algo, lo cual no escuché, He said something to me to which I did not listen [page 3207]

Hemos matado al ladron, We have killed the thief [page 3350]

Continued



Anderson

THE TRIUMPH OF VENICE, BY PAOLO VERONESE

[See Art]

THE GREAT ITALIAN MASTERS

The Efflorescence of Italian Painting. The Art of Filippo Lippi and Botticelli. The Umbrian School. Raphael, Andrea del Sarto, and Titian

Group 2
ART
26

HISTORY OF ART
continued from page 3678

By P. G. KONODY

RENAISSANCE painting, like architecture and sculpture, was born in Florence, and its cradle is the Brancacci Chapel in S. Maria Novella, with the frescoes of Masaccio, which have been the source from which many succeeding generations of artists drew their inspiration. It was the tendency of the Renaissance to give its due to the human body, to deliver it from the tyranny of the spirit, and Masaccio (A.D. 1401 to 1428) was the first of the painters to represent the nude living and in all its beauty and strength, as in the "Expulsion" and the "Baptism." He also departed from the generally prevailing practice of arranging the figures of his compositions in one row, in the manner of the ancient relief, or of placing them one above the other in diminishing size. His figures occupy their right places in the receding planes of the landscape and live in the surrounding atmosphere. They are full of dignity and expression, whilst the folds of their draperies have the amplitude of the best classic models. Altogether, his work marks an immense step forward in the direction first indicated by Giotto.

Filippo Lippi. His artistic heritage was divided among many of his followers, chief among whom is Fra Filippo Lippi, the worldly friar, whose love of life and beauty found expression in many exquisite easel pictures and in the fine frescoes at Prato and Spoleto Cathedrals. The emotions expressed by him are not purely spiritual, like those of Fra Angelico, but intensely human. A healthy, robust type of peasantry served for his models; and his sense of beauty and loveliness and pleasure in the joys of the world is reflected by the gay splendour of his palette. Domenico Veneziano, who is credited with the introduction of oil-painting in Italy, was, above all, a master of technique, a naturalistic painter whose chief concern was the pictorial rendering of movement and expression. Paolo Uccello was a scientist, chiefly absorbed in the investigation of the laws of perspective, and an excellent painter of horses, dogs, birds, and other animals. His colour was frequently quite arbitrary, and used almost in the manner of the mediæval illuminators. The National Gallery possesses an interesting battle picture from his brush, illustrating how the field of painting had widened since its liberation from the exclusive rule of the Church.

Representations of Contemporary Life. Under the cloak of scriptural illustration, Benozzo Gozzoli (A.D. 1420 to 1498), a follower of Fra Angelico, dealt in his extensive series of frescoes in the Pisan Campo Santo with general scenes of contemporary life, in which the customs, costumes, and types of his day are recorded with vivacious charm and great truth to Nature. [See page 725.] His frescoes at the Riccardo Palace represent a scene of gorgeous pageantry of fifteenth century Florence. Among those who were strongly influenced by Masaccio, the sculptors Verrocchio and Pollajuolo take a high place in the art of their time, though only few of their pictures have come down to us.

The Art of Botticelli. The Renaissance leaning towards classic learning found its supreme expression in Fra Filippo's pupil, Sandro Botticelli, one of the most personal and fascinating of the world's great masters. His strength lay in the marvellously expressive use of decorative line, the like of which can only be found in the art of Japan. He used colour not so much to deceive the eye into belief of the plastic reality of things as to strengthen the effect of the line. The rhythmic movement of the human figure in dance, the fluttering of drapery or of flowing locks in the wind, cannot be expressed more happily than in his "Allegory of Spring" [71] and "Venus Rising from the Sea." For his compositions he was more concerned with producing a beautiful decorative pattern than with making the figures live in their surroundings, which are frequently quite conventional. Botticelli was profoundly steeped in the "New Learning" of the period, and his pictures often show a curious blending of the Pagan and the Christian spirit. His "Madonna" [page 869] and his "Venus" present very much the same type of face—melancholy, timid, pure, scarcely beautiful, but intensely fascinating.

Filippino Lippi. Botticelli became in his turn the master of the latter's son, Filippino Lippi (A.D. 1457 to 1504), who combined many of his master's qualities with a sense of dainty beauty in expression and rich colour. In his earliest important work, the completion of the frescoes begun by Masaccio in S. Maria Novella, he tried with remarkable success to adapt himself to the manner of his great precursor; but in his later frescoes in the Strozzi Chapel he introduced such a florid mass of "Renaissance" detail, classic architectural motives with a tendency to over-decoration, Roman armour and trophies and instruments, that one is apt to overlook the really remarkable expressiveness in the varied gestures and movement of the figures. His most charming qualities appear quite unadulterated in such easel pictures as his "St. Bernhard," in the Badia in Florence [72], and the "Madonna with SS. Jerome and Dominic," at the National Gallery.

Pietro della Francesca (A.D. 1415 to 1495), of Borgo S. Sepolcro, in Tuscany, stands between the Florentine and the Umbrian schools. The transparent golden tone in which his landscape

71. ALLEGORY OF SPRING, BY BOTTICELLI *Anderson*

and figures are bathed in the earliest approach to the modern conception of painting open-air sunlight. He, too, was a master of perspective and foreshortening, and was endowed with a rare sense of pure beauty. One of his finest works, the "Baptism of Christ," is to be seen at the National Gallery. His pupil, Luca Signorelli, of Cortona, the author of a great series of frescoes at Orvieto Cathedral, may perhaps best be described as a painter of human limbs and of muscular activity. He delighted in illustrating scenes in which he could introduce seething, passionate crowds of unclothed humanity in every possible stage of violent movement; but he was not a painter of the "nude" in the modern sense—that is, an artist who will paint the figure for its beauty of form and surface texture. For that his drawing was too hard, his colour too dry; and the charm of the female form escaped his perception.

The Umbrian School. Umbrian painting was an offshoot of the Sienese school, modified by Florentine teaching. It never attained artistic independence, and was always more or less tied to the illustrative tendency. The Umbrians were more concerned with tenderness of sentiment and intensity of religious expression than with form and line and movement for their own sake. A long succession of minor artists, who need not here be enumerated, culminates in Pietro Perugino, the most typical, as he was the most accomplished master of the school. His scriptural pictures—and he painted few, if any, others—are peaceful, serene, detached from this world [73]. He painted the life of the soul and not of the body; and the lovely Umbrian landscapes in which his figures are set, landscapes that open up the whole depth of space, range after range of billowing hills under a limpid blue sky, only enhance the effect of pure spirituality. As a master of space composition he was only surpassed by his great pupil Raphael.

To the same school belongs Pinturicchio, one of the most productive fresco painters of the fifteenth century. The decoration of the Borgia apartments at the Vatican in Rome, and of the library of Siena Cathedral, are his chief works—masterly space compositions which, however, in their excessive love of splendour, of sumptuous gold, ultramarine and red, overstep the natural limitations of decorative wall paintings.

Influence of the Paduan School. Meanwhile, the Renaissance movement had made equal progress in Northern Italy. In Padua, Squarcione, a painter who had travelled in Greece and brought back with him a fine collection of antique sculptures, was the founder of a school based on the study of these antiques. His great pupil Mantegna (A.D. 1431 to 1506) was entirely imbued with the classic spirit, and treated his paintings in a noble, sculpturesque style which has much in common with relief work. His "Triumph of Cæsar," now at Hampton Court Palace, shows the extent of his classical and antiquarian knowledge and his masterly draughtsmanship, though his frescoes in the Gonzaga Palace at Mantua, which have for their subject scenes of contemporary life, show even better the power of his brush. The Paduan school exercised considerable influence over Milanese and Venetian art in the fifteenth century, particularly over Bramantino in Milan, and the Vivarini in Venice, though Venetian painting was soon directed into other channels.

The Splendour of Venice. The powerful mercantile Republic of Venice was never the soil for humanism that Florence had been. Accustomed to gorgeous pageants, pomp and ceremony, and luxurious life, and living in an atmosphere that cannot but develop a keen sense of beautiful mellow colour, these wealthy traders required an art that should be neither academic nor didactic, an art that should not reflect classic knowledge or stimulate thought, but an art that should reflect the splendour of their daily surroundings and appeal direct to the senses through the musical quality of colour. In Florentine painting colour had always been subordinate to line; the Venetians were the first school of real colourists—painters who thought in colour, not in line; who studied the colour appearance of Nature, and rendered the true appearance of things in pigment—true painters, in fact, in the modern sense of the word. The introduction of oil-painting by Antonello da Messina was of inestimable advantage to the achievement of this new ideal in painting.

The Bellinis. The brothers Giovanni and Gentile Bellini show already the germ of the Venetian tendencies which were to culminate in Titian and Tintoretto. Gentile revelled in historical processional pictures of Venetian life, a type of work in which Vittore Carpaccio achieved the greatest fame. Giovanni Bellini's paintings have a noble, classic dignity of style, an almost monumental character. He strove for the typical rather than the individual. His colour is rich and harmonious, though not as sensuous as that of the later masters. Two other masters of the earlier Venetian school must here be mentioned—Carlo Crivelli, a pupil of the elder Vivarini, and strongly influenced by Mantegna; and Cima da Conegliano, whose altar-pieces are full of character and glowing colour. Crivelli, whose love of carefully executed detail rivals the early Flemish masters, is magnificently represented at the National Gallery.

Towards the end of the fifteenth century there was scarcely a city in Italy that was not a centre of some important school, and could not boast of some masters of more than local reputation. When the sixteenth century dawned, painting, though still frequently employed for the decoration of architecture, had to a great extent become an end in itself, independent of the other arts.

Lionardo and Raphael. Leaving Venice and returning to Florence and Central Italy, we come to the man who inaugurated the greatest period in Italian art—the period when supreme technical mastery went hand in hand with ideal beauty and classic perfection. This man was Lionardo da Vinci, that universal genius who could master and achieve greatness in every phase of intellectual and artistic activity. Raphael was an eclectic who, gifted by nature with a rare capacity for assimilating all that was most admirable in the art of those that had gone before him, consciously combined these qualities in works that have for centuries been held up as the acme of perfection, and have, through academic teaching which encourages the cold, soulless imitation of all that is purely formal, exercised a deterrent influence on the evolution of art. Lionardo, too, had assimilated the accumulated experience of two centuries of painting, but with him this process was unconscious, and though the perfection of his work sounds a unique personal note, there was nothing his brush could not express—emotion or serenity, character or pure beauty, strength or tenderness. He was a master of line and of colour, of movement and expression. Volumes have been

Anderson

72. APPEARANCE OF THE VIRGIN MARY TO ST. BERNHARD, BY FILIPPINO LIPPI

written about the deep significance of every figure in his "Last Supper" fresco, in Milan, now a complete wreck, which scarcely reflects a dim shadow of its former glory. And the mysterious enigmatic smile of the "Monna Lisa" has become the stock phrase of a generation of art writers [76].

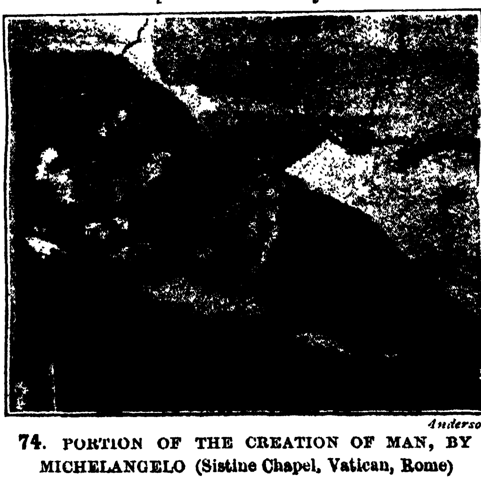
Called to the Court of the Sforza in Milan, Lionardo became the head of an important school, from which issued such masters as Luini, Beltraffio, Gaudenzio Ferrari, and the Sienese painter Sodoma. Lionardo himself produced but few finished works, and forms in this respect a marked contrast to his great rival Michelangelo, whose work is truly titanic in character and in extent. His ceiling of the Sistine Chapel alone would be no inconsiderable result [74] of a life's work. We have already dealt with the master's sculpture. In painting he shows the same powerful grasp of the human form, the same passionately heightened vitality, the same grandeur of design. But he was not a colourist in the sense of the Venetians, or of Lionardo. His genius was more sculptural than pictorial. His strong personality attracted many followers, of whom Sebastiano del Piombo achieved great fame, and even Raphael at one period fell under his spell.

Mansell

73. THE VIRGIN ADORING, BY PERUGINO (National Gallery, London)

"The Perfect Painter." Of the other Florentines of the period, Fra Bartolommeo and Andrea del Sarto enjoy the widest fame. The former, a follower of Savonarola's, eschewed all worldliness in his art, and painted in his early period many serious and solemn altar-pieces of great beauty and harmoniously blended, mellow colour, though later in life he attempted more ambitious works of pompous character, but without much significance. Andrea del Sarto, who earned the epithet of "the perfect painter," approached the Venetians in his conception of colour. Perfect in drawing, with a rare sense of beauty and grace, he lacked power of expression and depth of feeling. In Northern Italy, Correggio, whose chief works are to be seen in Parma, is the most typical master of the late Renaissance. An artist of great nervous sensibility, he had little concern with nobility of form and carefully-measured rhythm of line. His art is intensely emotional; the expression of his "Madonna," as of his "Magdalen" and his "Io," is almost ecstatic in its intensity of delight or grief. His real medium is light and shade rather than colour and line, and he almost rivals Rembrandt in his rendering of chiaroscuro.

Raphael marks the turning-point of Italian art—Venice always excepted—which after his death degenerates into eclectic mannerism on the one hand and crude naturalism on the other. Of Raphael's pupils, Giulio Romano and Perino del Vaga continued for a while his tradition, but towards the end of the century Bologna took the lead. The Caracci and Guido Reni and Sassoferrato and other eclectics are, however, scarcely worthy of a place in a short survey of the world's art, except to typify the shallow depth to which painting had sunk after its glorious efflorescence at the beginning of the century. The naturalists flourished especially in Naples, where Ribera painted numerous scenes of torture and other horrors with bold use of contrasts of light and shade.



Anderson

74. PORTION OF THE CREATION OF MAN, BY MICHELANGELO (Sistine Chapel, Vatican, Rome)

Giorgione. In Venice the sixteenth century is inaugurated by three glorious masters—Giorgione, Palma, and Titian. Of the first of them only few pictures can be identified with certainty, but they

suffice to secure him a position among the elect. He knew how to express the emotion of the figures in the surrounding landscape; he was the first, in fact, that did not paint the background merely to fill in a pleasing manner the space between and behind the figures, but made the figures live in their surroundings. He was an idealist whose art was the fruit of his imagination.

Palma. Palma, who owed much to Giorgione's example, was intoxicated with the sensuous beauty of Venice and of her daughters, and revelled in painting the luxurious charm of their rounded forms and golden hair [75].

75. THREE SISTERS, BY PALMA VECCHIO
(Dresden Gallery)

Titian. Titian stands for the highest achievement of Venetian art. He was, perhaps, the greatest colourist the world has ever seen, and could do justice to every task by which a painter may be confronted. That he could express in terms of colour the most exalted emotions of the human soul is proved by such works as his "Assumption," at the Venice Academy [see page 181]. In space composition he rivalled the greatest Tuscans. The sumptuous glow of his colour is only rivalled by the rhythm of his linear composition, and in portraiture he ranks with Velasquez and Rembrandt.

Tintoretto and Paolo Veronese. While in the later part of the sixteenth century the rest of Italy was given over to uninspired eclecticism, Tintoretto and Paolo Veronese worthily upheld the great tradition of Venetian painting. The former, who had chosen the motto, "The design of Michelangelo, the colour of Titian," was endowed with a fecund imagination, was a complete master of the human form, and of all effects of light, and a gigantic worker, who devoted himself with preference to decorative tasks on a monumental scale. His principal works were executed for the Doge's Palace and the Scuola di San Rocco, in Venice. Paolo Veronese, one of the greatest masters of composition and a sumptuous colourist, was above all the painter of Venetian festive life. His subjects, true enough, are chosen from Scripture, but the scenes are invariably clad in the gorgeous costume of sixteenth century Venice, which they bring vividly before our eyes. He loved the beautiful surface appearance of things, and did not trouble much about their inner meaning. [See Plate facing 3793.]

76. MONNA LISA, BY LIONARDO DA VINCI
(The Louvre, Paris)

Canaletto. Tintoretto and Veronese are followed by many florid imitators, but the end of the seventeenth century produced a new "genre," of which the elder Canaletto is the chief representative. He was a purely objective painter of the architectural features of this floating city of palaces, which he recorded with great love of detail, without losing sight of the effect of massed light and shade. Francesco Guardi chose similar motifs for his pictures, but treated them in a less topographical spirit. His brush is more liquid and broad, his tone silvery and creamy, his atmosphere truer than Canaletto's.

Tiepolo. The last of the masters of Venice was Tiepolo (1696-1770), who catered for the craving of his time for florid splendour—a great colourist, who modelled himself on his greater precursors of the sixteenth century, but totally lacking in ideas and expressiveness. He devoted himself chiefly to decorative paintings for ceilings and walls, and died in Spain, whither he had been summoned as painter to the Court of Madrid.

Continued

THE VITAL NEED OF PURE AIR

Pure Air is Essential to Health. Sources of Impurity in the Atmosphere. Rain, Sunshine, and Wind as Purifiers. Poisonous Air in our Homes

By Dr. A. T. SCHOFIELD

INORGANIC particles form the third class of impurities in air and include lead, arsenic, zinc, copper, brass, sand, chalk, phosphate of lime, clay, coal, rust, dust of glass, and in special trades dust from saw grinders, cutters, miners, potters, watchmakers and paint workers.

The Evil of Dust. Dust is a great evil as well as a nuisance. It has lately increased greatly in our country roads owing to motor traffic, and has become such a danger and annoyance that it must certainly be lessened, partly by improved structure of vehicles, and partly by a more dustless construction of roads. In towns it has changed in character with the introduction of wood pavements, the ground-up fibres of which make an irritating dust when dry, and a most tenacious mud when wet.

Dust is of three principal varieties—nutritious, harmless and hurtful. Amongst nutritious dusts are those of bakeries, bone mills, and wood turneries. It is said that wood dust actually fattens. Amongst dusts that are, on the whole, harmless, we are glad to reckon coal. Were this not so, life in cities would be very fatal. Anyone who has seen the appearance after death of a Londoner's lungs and a countryman's cannot but be struck with the great difference. The Londoner's lungs are of a greenish black, and are full of grit everywhere, apparently choked with it, and yet the man lives and dies without his respiration suffering; but those of the countryman are a fresh pink, and quite clean. The reason coal dust does not injure and tear the lungs is because the corners of the little particles are not sharp, but rounded. London air is not, therefore, primarily unhealthy on account of the coal dust it contains, but on account of the organic poisons with which it is laden.

Many Kinds of Dust. Hurtful dusts are of several classes—vegetable, mineral, chemical and animal. There are in the first place those that are *vegetable irritants*, which are of no great account unless constantly breathed for a prolonged period. Such is the dust from wool, hair, silk, cotton, flax, hemp and jute mills.

We then get *mineral irritants*, such as dust from stone, glass and sand, and also from metals—steel, iron, and tin dusts, which are very irritating. The peculiar danger of knife grinders' dust is that the trade is conducted in draughty buildings, predisposing to colds and chills, and the dust itself constantly inhaled is a mixture of stone grit and steel dust. These irritating dusts are liable to set up some form of consumption.

It is found that coal-miners have least respiratory diseases, thus showing that coal dust is harmless; while tin-miners are the worst sufferers from lung diseases, which are four times as numerous among them as among coal-miners. Next, we get potters and file makers and cutters, three times as numerous; and then quarrymen and wool and cotton factory hands, twice as numerous. There are, besides, poisonous chemical dusts, such as bleaching powder, bichromate of potash, white lead, phosphorus, and arsenical wall-papers. Besides phthisis, lead dust produces colic; the dust of copper and brass, etc., produces ague, and that of phosphorus causes diseases of the jawbone.

Lastly, and most pernicious of all, there are all sorts of septic animal dusts from hospitals and diseased persons, from manure works, from hides, and from all decomposing animal refuse. Some of the worst of these are the numerous dried particles of expectoration from diseased people, and it is in consequence of this that vigorous efforts are being put forth to make expectoration in public places an offence.

The immediate vicinity of graveyards, brickfields, and infectious hospitals has sometimes a bad effect on health by causing impurities in the air; also the proximity of chemical works and offensive trades.

Breathing as a Source of Impurity. We will now look briefly at the leading sources of these impurities, which are respiration, combustion, stagnation, trades, towns, marshes and invalids.

Of all these sources, respiration—or, rather, expiration—is the chief. In *expiration* each person, if at rest, gives out about ·6 cubic feet of CO_2 per hour, or 16 cubic ft. of CO_2 per day. If the person be at work, much more CO_2 is given out, as the amount rises in proportion to the amount of work done. In hard work it will rise to as much as 1·5 cubic ft. per hour. The expired air, being also laden with moisture, saturates the air with water vapour.

But, besides this, the expired breath is laden with effete animal refuse, and it is *this*, with CO_2, that makes it so pernicious. We have, therefore, three changes in it produced by respiration—it becomes laden with CO_2, with water, and with animal refuse.

It is computed that 2,000 people in one hour produce carbonic acid gas containing 1 cwt. of pure carbon and about 17 gallons of water. The animal matter given off is so poisonous that, if this breath be condensed on the wall of a close room in the form of drops of water, one single drop of the fluid will poison a rabbit.

The skin of the body also expires, or perspires, and from this source also a vast mass of impurities enters the air.

Various Causes of Impure Air. Combustion is another cause of impurity. The

burning of gas, lights, and coal fires produces carbonic acid and other gases. But we must note that carbonic acid gas produced in this way is very different from that produced by expiration, for it is free from all poisonous organic particles.

Stagnant air has a diminution of oxygen and an increase of CO_2, and in fogs a great deal of solid matter is suspended.

Trades give off innumerable particles and poisonous gases, and need not be enumerated.

Towns are another source of impurities on account of the crowded life and the indoor existence. In a room there are ten times as many bacteria in the air as there are in town air; and in town air there are ten times as many bacteria as there are in country air.

In addition there is household dust of every sort, and street dust laden with particles of manure.

Poisonous exhalations emanate from marshes, which are also the birth-place of insects that cause malaria.

Invalids are ever giving off exhalations of a specially poisonous nature, while in all infectious diseases the air is laden with contagious particles.

The Health Value of Rain. Agents which cleanse the air from these defilements are rain, ventilation (external and internal), prevention of smoke, plants, sunshine and wind.

Rain is a great purifier of air; how great, but few realise. Perhaps one of the best ways to prove this is to go out with a white waistcoat on a dry day and on a wet day. If rain be prevented from falling on the waistcoat, it will keep quite clean on a wet day Another test is the difference in the taste of the air after rain, for air breathed through the mouth has a decided taste. If we examine rain-water, we shall find it filled with impurities which it has washed down from the air.

In the best systems of ventilation of churches and other large buildings, one of the processes is to wash all the air that is admitted by imitation rain (water running down a fine string screen), thus ensuring its purity. It is therefore fortunate for us in one way that this is such a rainy climate, for there is no doubt that from this cause town air is much purer than it would otherwise be.

A combination of rain and electricity, as in a thunderstorm, not only purifies the air, but refreshes it by storing it with ozone. The air in towns, therefore, is at its best and purest after such a cleansing storm.

Air in Towns. *External ventilation* consists in the ventilation of towns by the abolition of courts, cul-de-sacs and narrow streets. To secure the best air in a town, it should have plenty of parks, and streets 36 ft. wide, with footpaths 24 ft., making at least 60 ft. between the houses, but no back-to-back houses and no places without a through draught. We must remember that the air when it first reaches a town is country air. It is a curious fact that in so many of our towns the west end is the fashionable quarter, and on investigation it is found that this is connected with the question of external ventilation, for in towns where the west end is the fashionable suburb the prevailing wind comes from the west. It is evident, therefore, that those who dwell in this locality get the purest air, for they get it just fresh from the country, whereas those in the east only get it when it has passed over the whole city. *Internal ventilation*, or ventilation proper, is the other aspect of the subject.

The prevention and consumption of smoke are both of great importance, and not only make a town cleaner and brighter, but, through more perfect combustion and decreased use of raw coal, prevent many deleterious products, especially sulphur fumes, from entering the air. It is comparatively an easy matter to prevent smoke in factories; the difficulty is to do away with it in private houses. The remedy will probably come from the supply of electricity at so cheap a rate that heating will be largely done by its means.

Nature's Purifying Agents. Plants, of course, absorb CO_2, and give out oxygen, so that, theoretically, sufficient plants to absorb the CO_2 given out by a man should keep the air perfectly pure. Anyhow, there is no doubt that trees in the parks and in the streets of a city are of great use, and assist in purifying the air.

The sun is a mighty purifier. Not only by its heat and its light, but by the chemical action of its actinic rays, it rapidly burns up and destroys the germs that swarm in the air. It does another thing. It makes the dirt visible, and a person who walks through a sunbeam, where the air, thick with dust of all kinds, can be plainly seen, distinctly hesitates before he breathes such a thick and nasty compound.

The last purifier of which we have to speak is wind. We must, however, point out that it is also a great introducer of impurities as well as a remover of them by assisting ventilation. When all the road-sweepings are blown up in clouds, and all the dust whirls round in eddies, the wind is scarcely acting as a purifier. The steady breezes, which, without so much as raising the dust, cause the air to move rapidly, do much good. Air frequently by this aid travels 10 to 14 miles an hour. If you stand in Oxford Street, with such a west wind blowing, the air you breathe is hardly town air at all, for it was over Wimbledon and Barnes Commons a few minutes before, and the town air is quickly blown out to be purified in the country. Wind, therefore, is of the greatest value, for nothing can be worse than stagnant air.

Air Indoors. Some idea will have been formed by now how far we are from breathing pure air out-of-doors, in towns, at any rate; but all this is as nothing compared to the quality of the air indoors, on which we have not yet touched.

There is one country in the world in a high state of civilisation where the question of ventilation is of no importance, and that is Japan. Here, owing to the paper walls of the houses and rooms, and their extraordinary mobility, the air indoors and out-of-doors is more easily kept alike than anywhere else; and it is quite possible that in our intimate associations with

Japan we may find some principles that could be adopted with advantage even here.

Of course, our great difficulty in England is not only the solidity of our houses, but the inclemency and changeableness of our climate, in which nearly every attempt at ventilation causes a horrid draught.

Ventilation is, of course, the science of effectually changing the air indoors *without draught*, and it is a science of the greatest importance to the health and well-being of this country.

Out-of-doors the air is generally in more or less rapid movement, and thus, even in the heart of London, fresh breezes from the country, travelling at from 10 to 15 miles an hour, frequently come from the fields and flowers, and the air is being continually changed. The largest crowd cannot make the air close, and it is only when it is allowed to stagnate that it becomes injurious. Hence the danger of courts and alleys which have only one entrance, the building of which is now wisely forbidden. No; the evil really lies in the extraordinary folly we display in our dwellings, where, as a rule, with every arrangement for comfort and even luxury, none is definitely made indoors for securing pure air for the breath of life.

Poisonous Cottages in Fine Air. It is certainly startling to find what numbers of people are thus poisoned in the finest air in the world. In the country, and in Scotland especially, the death rate from consumption is very high amongst the women in proportion to the men; and this is undoubtedly due to the indoor life of the former as compared with the latter, for any greater contrast between the air of a Highland moor and that of a Highland cottage it would be hard to conceive. It is for a similar reason that so many people derive small benefit from their seaside change. They spend half their time—their nights, at any rate—in such small, stuffy, over-crowded and poisonous rooms, with windows that do not open at the top, that the good of the fresh breezes of the day is quite undone.

In the Hebrides, consumption is almost unknown, for the cabins there, built of unhewn stones, allow an abundance of fresh air to enter, while a great square hole, 18 in. in diameter, in the roof, carries off all the foul air. On a large estate on the mainland, where this primitive state of things was with the best intentions done away with, and the rough shanties were replaced with neat cottages, whose walls and roofs were hermetically sealed with plaster and whitewash, and whose windows and doors were close-fitting, the mortality speedily increased, in spite of the greater comfort thus afforded.

Air in Hospitals. Years ago, in the Franco-Prussian War, numbers of the wounded soldiers were placed in draughty barns, the hospitals being over-crowded. Cold and comfortless as these barns were, those who were in them got well more quickly than those who were in hospital, simply because they had more fresh air; and similar experiences have repeatedly occurred in other wars. It cannot be too much insisted on that close air is as poison to the sick.

With regard to the necessity of providing pure air in our houses, there is another thought which will bear repeating. As to our food, we can go about and select it when and where we will, and eat it at certain times; as to our clothes, we can choose them where and when we will with equal ease; but as to the breath of life, we are compelled by an inexorable law of Nature to draw in whatever air we happen to be standing in, about 17 times every minute of our lives, day and night, without ceasing, or about 9,000,000 times every year, whether it be pure or poisonous. What an amazing importance, then, attaches to this one question of ventilation!

Gradual Poisoning by Vitiated Air. Another fact also shows the vital importance of thoroughly understanding this subject. The poison of carbonic acid gas is like those poisons (arsenic, etc.) selected by scientific murderers for their victims, in that it is insidious and gradual in its action. By constant habit, greater and greater quantities of it can be taken, profoundly injuring the whole system, though not absolutely destroying life. There are many rooms in which we live, and especially in which we sleep, which get in such a state that a person introduced into them from the open air is nearly stifled.

The reader will soon demonstrate this if, some morning, he will get up and dress and go straight out-of-doors for a few minutes, shutting up the unventilated bed-room, and then return and shut himself up in it and try to breathe.

It must never, however, be imagined that because we can get accustomed to poison, *it does us no injury*. The contrary is the case, and chronic slow poisoning is the worst.

The constant breathing of impure air produces blood-poisoning of the most profound description, known as anæmia. In this terrible disease, all colour goes from the face, and even from the lips and gums; the breath is short, the blood itself watery, and the whole system a prey to other passing diseases.

The Vital Need of Our Lives. It cannot be too widely known that we owe our lives to the power the fresh air has of entering a room and the foul air of leaving it. If a man enters a large dining-room and seals up door, window and chimney, he can exist one hour on the air it contains and no longer; then he will die. His life does not depend on the size of the room, but on its ventilation, and this people so often forget.

Ventilation, then, is the process of introducing into our rooms pure air for inspiration and getting rid of the impure air of expiration freely and without draughts.

One very great difficulty exists with regard to all ventilation, and especially amongst that class whose health is really their wealth and capital, those who earn their daily bread by hard work in towns. We must remember that fresh air is cold, and that impure air, as it is breathed out of our lungs, is warm, nearly blood heat, or 98°, and it is this fact which constitutes the fundamental difficulty in ventilation.

The Royal Commission of 1885 on the Housing of the Working Classes wisely recognises this, and says: "It must never be forgotten that the human body has a desire and a need for warmth, and that fresh air, which is so necessary to the health of a well-nurtured body, chills the half-starved, ill-clad frames of men and women whose homes have been described."

Fresh Air Costs Money! The simple truth is this. The poor find out that by far the cheapest way of warming a room is by their own breath, and they therefore stuff up every crack and crevice, close door and window, and crowd closely together, rigorously keeping out that on which their very life depends —pure air. And were it not for the chimneys in most rooms, deaths directly from this cause would be far more common than they are. Even at sea, some of the foulest air in the world is to be found in the seamen's cabins in the forecastle, which are warmed by the same poisonous means. The difference between pure warm air and foul warm air cannot be too strongly insisted on, and the fatal effects of living or sleeping in close rooms, warmed by the heat of one's own poisonous breath, too plainly pointed out. It is a matter of pounds, shillings, and pence, and the pity is that those who need this pure air most are those who have least of these three things to spare. If the room is to be kept fresh and pure, more coals must be burnt, or more clothes worn, or both.

It is curious, seeing the enormous importance of this subject, that it has not yet been found possible to apply to the dwellings of the poor any simple way of warming the fresh air as it enters a room. Some of the rich who can afford it adopt a Galton grate, which does this by admitting the fresh air at its *sides*; but we still think that in the vast blocks of model dwellings rising all over London some way might be found of economically laying on warm fresh air to a flat from a central furnace.

In schools a wholesome horror of rebreathed air should be vigorously inculcated, and its deadly effect shown by experiment, so that when the children grow up, nothing will tempt them to live in close rooms and breathe foul air. Carbonic acid gas, produced by the various functions of life in our bodies, and breathed out with every breath, is a powerful brain and nerve poison. Its effects are intensified when combined with the germs in expired air.

Effects of Poisoned Air. It is this, too, and not always the sermon, that makes people so sleepy in churches and chapels. It is this, and not the lesson, that makes children so listless and fidgety in ill-ventilated schools. It is this, and not hard work, that makes people so dull and heavy when they wake in the morning. It is this, and not mere temper, that makes the wife or the work-girl who has been working in a close room all day so irritable. The need for ventilation is so pressing, as we have shown, that efforts will never cease to come nearer and nearer to an ideal. That ideal is to make indoor air in the country as pure as outdoor air.

It must be remembered that that is the problem —since the foulest outdoor air is purer than the best indoor; and the evil of cities is not the air of their streets, but the indoor lives of their inhabitants. Now, the air out-of-doors contains ·04 per cent. of CO_2, and it has long been found that to attain this standard of purity indoors is practically impossible. By common consent, therefore, the standard of pure indoor air has been made to differ from outdoor; for the former has been raised to ·06 per cent. CO_2, while the latter is ·04 per cent. CO_2. Perfect ventilation may therefore be defined roughly as the science of keeping indoor air below ·06 per cent. CO_2 without causing a perceptible draught.

If indoor air on the average had to be kept actually as pure as outdoor air, about 100,000 cubic ft. per hour should be supplied, which means a movement of 17 ft. per second; but in this climate any movement of the air of over 6 ft. per second produces a draught, and the air must be changed without draught, which shows the necessity of the compromise.

An Analysis of London Air. Outdoor air in the New Cut has 4 parts CO_2 in 10,000.

The following are specimens of indoor air:

Ventilated and fresh ..	6	parts CO_2 in 10,000
Rather close	8	,, ,,
Close	10	,, ,,
Very close	13	,, ,,
Close bed-room	15	,, ,,
Foul by smell	17	,, ,,
Pit of crowded theatre	20	,, ,,
Box of crowded theatre	30	,, ,,
Crowded school-room ..	37	,, ,,

The Metropolitan Railway in some parts has 15 parts CO_2 in 10,000.

These results are produced in various ways, of which a rough outline has been previously given, but it may be considered a little further here.

The following are the amounts of CO_2 given off and air used per hour by—

Man	Cubic feet CO_2.	Cubic feet air.	Woman	Cubic feet CO_2.	Cubic feet air.	Child	Cubic feet CO_2.	Cubic feet air.
	Per hour.	Per hour.		Per hour.	Per hour.		Per hour.	Per hour.
Repose ..	·6	3,000	Repose ..	·4	2,000	Repose ..	·3	1,500
Work ..	1·1	4,500	Work ..	·6	3,000	Work or play	·5	2,250
Hard Work	1·6	9,000	Hard Work	1·2	6,000	Hard work or play	1·1	4,500

Now, the maximum addition to outdoor air for *pure* indoor air is ·2 CO_2 per 1,000 ft. If a man gives out ·6 CO_2 per hour, and only ·2 CO_2 can be put into each 1,000 ft., it is evident that he must have 3,000 cubic ft. outdoor air per hour supplied to him to put it in. This is the foundation-stone of all ventilation.

Combustion is the next impurity to consider. Two gas burners produce 6·0 cubic ft. CO_2 per hour, or as much as 10 men. If, therefore, a man were shut closely up in a small room he could live one hour in the dark; with a candle three-quarters of an hour; with a lamp half an hour; and with two good gas lights five minutes! But the CO_2 from gas is so pure, as compared with that from human beings, that in this case each cubic foot of CO_2 requires only 90 cubic ft. of air to dilute it per hour.

A Test for Pure Air. Every cubic foot of gas burnt produces half a cubic foot CO_2 and requires 450 cubic ft. of air to dilute, besides fresh air needed for respirating impurities. A simple test for pure indoor air is to fill two bottles (half-pint) with water and empty them in the room you wish to test, so that the air of the room takes the place of the water. Then to one bottle add one tablespoonful of limewater, cork the bottle, and shake it well. If the limewater remains clear the air is pure, and the CO_2 in it is very much under ·06 per cent. If it becomes milky it is impure, the air containing over ·06 per cent. CO_2.

To the second bottle full of air add two tablespoonfuls of Condy's Fluid and shake it. If the colour remains, the air is pure; if it disappears or changes to dirty brown, there is excess of organic impurity in the air.

Cattle require three times as much air as men; a pig the same. The sick require at least a quarter more than the healthy.

Let us look, now, at the ideal and the actual allowance of cubic space of air.

The Air Space We Need. Pure indoor air at 61° contains not more than ·06 per cent. per 1,000 cubic ft. of CO_2 and 75 per cent. of its capacity of water vapour. To maintain this, theoretically, requires a supply of 3,000 cubic ft. of fresh air per hour per human being. It is found, moreover, that, as air can only be changed in this climate three times an hour without draughts, 1,000 cubic ft. of air space is required to admit of the circulation of 3,000 cubic ft. per hour. It is very seldom, however, that 1,000 cubic ft. is allowed. A man himself takes up 3 cubic ft.: a bed, 10.

A common allowance of air space in certain buildings is as follows: factories, 400 cubic ft.; lodging houses, 240 cubic ft.; public schools and barracks, 600 cubic ft.; hospitals, 1,200 cubic ft.; some London schools, 130 cubic ft.; some Edinburgh schools, 100 cubic ft.; prisons, 860 cubic ft.; infectious hospitals, 2,000 cubic ft.

It has been found in schools that with 230 cubic ft. per head there was ·14 per cent. CO_2, being an excess of ·08 per cent. (with two ventilators open); with 200 cubic ft. per head there was ·32 per cent. CO_2, being an excess of ·26 per cent.; with 100 cubic ft. per head there was ·37 per cent. CO_2, being an excess of ·31 per cent. (with one small ventilator)

This state of things is being improved every year as the principles of good ventilation are more and more widely practised.

Small rooms actually get much more impure than larger ones, even when air is changed at the same rate, owing to the little diffusion, and the clinging of the organic matter to the walls.

Change of Air in Rooms. The rapidity of the change of air in a room practically depends mainly on the difference between the inside and outside temperatures. The mere existence of an opening does *not* make air move. It is when a room is hot and the atmosphere cold that air is drawn in in such quantities. Hence, a small aperture in winter lets in as much air as a larger one in summer. Indeed, there are days when, with all the doors and windows open, the air does not move, and any purification is by diffusion, and not by currents of air.

Air comes direct through walls. It was found that a closed room, containing 3,000 cubic ft., had its entire air changed in one hour when the inside temperature was 65° and the outside 32°. Air should not move more than 5 ft. a second in this climate if there is to be no draught. The opening to admit fresh air for each person is thus 24 sq. in., and is worked out in this way.

Twenty-four square inches is one-sixth of a square foot of 144 in., and if the air moves at 5 ft. per second, five-sixths of a square foot enters this aperture per second; or per hour (60 × 60), 3,000 sq. ft., which is just the amount required by one person. Practically, therefore, seeing 24 in. is a space 6 in. by 4 in., a window 4 ft. wide—*i.e.*, 6 × 8 in.—open 4 in., gives entrance to enough fresh air to supply eight people in a room. Of course, this is without lights. Theoretically, therefore, at night when the lights are on, the operation should be increased; practically, it is decreased; hence, the air in a room is nearly always much fouler at night than in the day.

We are now in a position to consider intelligently the question of natural ventilation; by this we mean the natural movements of air as distinguished from artificial ventilation, by which the air is extracted or pumped in.

Continued

continued from page 3727

SPIDERS, LOBSTERS, & CRABS

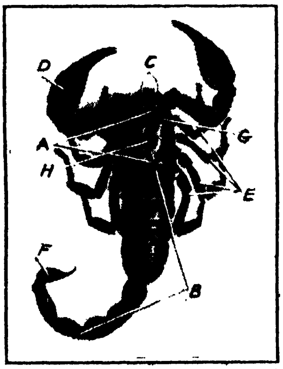
Scorpions and their Poison-bags. Spiders. Mites. Gill Bearers. Lobsters, Crabs, and Hermit-crabs. Water-fleas and Barnacles

By Professor J. R. AINSWORTH DAVIS

Scorpions and Spiders

Arachnids (including scorpions, spiders, mites, etc.), though sometimes popularly confounded with insects, differ from them in a number of ways, some of which are sufficiently obvious. The head and thorax are always fused together, and the former does not bear slender feelers (*antennæ*); there are four pairs of walking legs; wings are never present; and the young, when hatched, resemble the adult in form.

Scorpions. Scorpions [**486** and **487**] are characteristic of the hotter parts of the globe, but some of the smaller species live in South Europe. Here, as in Arachnids generally, the rings or segments which make up the head and thorax are so intimately fused together that their boundaries cannot be seen. The segments of the abdomen, however, are very clearly demarcated [**486**], and it is characteristic of scorpions that this region should consist of a broad basal part followed by a narrow "tail," at the end of which a sharp curved sting is situated.



486. SCORPION (UPPER SIDE)
a. Head and thorax *b.* Abdomen *c.* Chelicerae *d.* Pedipalp *e.* Walking legs *f.* Sting *g.* Front eyes *h.* Central eyes

The food consists chiefly of insects and spiders, as well as of other small creatures. These are seized by means of the first two pairs of appendages, situated in front of the walking-legs. The first (*chelicerœ*) are short and terminate in sharp nippers, while the much larger second appendages (*pedipalpi*) bear large pincers resembling those of a crab. Having seized a victim, the scorpion raises the narrow tail over the back and brings the sting into operation. Near the sharp tip of this two little poison-bags open, and their secretion being injected into the wound immediately proves fatal. The prey is not chewed and swallowed, but its juices are extracted, the stomach of the scorpion being a sort of suction-pump and its mouth exceedingly minute.

Midnight Marauders. Scorpions lurk under stones and in other dark places, and are nocturnal in their habits. In colour they are mostly dull—or even black, harmonising with their surroundings, and thus securing a measure of protection as well as being made inconspicuous to their prey. There are two eyes on the top of the head, in the middle, and two groups of somewhat simpler ones on either side, at the front corners of the same region. These, however, do not seem to be particularly efficient. On the under side of the body, just behind the last walking-legs, are two curious comb-shaped structures representing a modified pair of limbs, and probably serving as organs of touch [**487***a*].

A scorpion does not breathe, like an insect, by means of air-tubes, but by four pairs of lung-books, the slits opening into which are easily seen on the under side of the broad region of the abdomen [**487***b*]. A large number of delicate plates, resembling the leaves of a book, project into each of them, and hence the name *lung-book*. It is in these that the blood is purified.

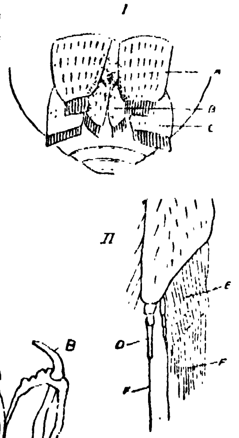
Spiders. These familiar animals differ from scorpions in several respects, as a glance at **495** will clearly show. The abdomen, instead of being elongated and clearly divided into rings, is a rounded mass in which the boundaries between these are not visible. The jaws do not terminate in pincers, but, in the first pair (*chelicerœ*), the end-joint can be bent down for grasping purposes like the blade of a pocket-knife [**488**]. The second jaws serve as feelers. There are from six to eight simple eyes upon the top of the head.

487. SCORPION (UNDER SIDE)
a. Comb *b.* Openings of lung-books
(Photographs by Prof. B. H. Bentley)

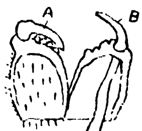
Spiders are fully as rapacious as scorpions, and like them they suck the juices of their victims, which are killed or paralysed by the secretion of poison-glands that open upon the first jaws, and thus compensate for the absence of a tail-sting. The colours and markings, as in scorpions, make these creatures inconspicuous, serving the same double purpose. Breathing is effected either by four lung-books, or, more commonly, by two of these organs together with air-tubes resembling those of insects.

Web-spiders. The most familiar spiders construct webs of various kinds to serve as snares for their insect prey, a device which fully compensates for the absence of wings. Taking the common garden spider (*Epeira*

diadema) as a type, we shall find that the silk-glands open on six little teat-like projections, the spinnerets, situated on the under side of the abdomen near its hinder end [489]. The ends of these are studded with about 600 minute tubes, some larger than the rest. The fluid which exudes from each of these at once hardens into a thread of almost inconceivable tenuity. Every line of the web is exceedingly complex, for it consists of some 600 strands woven together. Hardening takes place much more quickly than if it were in one piece, and it is also very much stronger than it would otherwise be. And yet it is so exceedingly delicate that it is very much finer than the most delicate human hair.

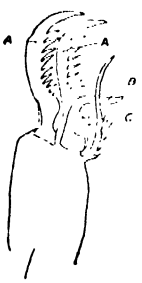


489. SPINNERETS OF GARDEN SPIDER
I.—*a.* Front, *b.* middle, and *c.* hind spinneret II.—*d.* Large, and *e.* small silk tubes of a middle spinneret *f.* Threads (much enlarged)



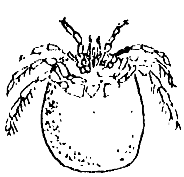
488. CHELICERÆ OF SPIDER
a. End joint of left, turned down *b.* End of right, turned up *c.* Poison gland

Making the Web. The web of the garden spider, noted for its great beauty and regularity, is vertically disposed in a hedge or some other convenient place, often in the neighbourhood of water, where flies and gnats abound. The web is made by the female. To begin with, a roughly four-sided quadrangular *frame* is constructed, the upper side being made first [490]. Fixing the beginning of this thread (A) to a support, the spider crawls horizontally to a convenient distance, spinning as she goes, pulls it taut, and then attaches its other end. The other three sides of the frame (B, C, D) are constructed in a similar fashion.



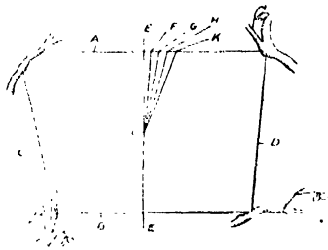
491. FOOT OF SPIDER
a. Climbing claws *b.* Walking claw *c.* Toothed bristle

The second or radial part of the web, arranged like the spokes of a wheel, next receives attention. Climbing to the middle of the upper side of the frame the spider fixes to this a thread (E) and drops down to the lower side of the frame, where the other end is made fast. Ascending to the middle (O) of this vertical thread, she attaches a new one and, ascending to the top of the frame, pulls it tight and fixes it at a suitable distance from the vertical one (F). There are now three completed radial threads, two of which are the upper and lower halves of the vertical line. The radial part of the web is completed in similar fashion.



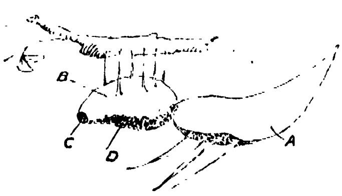
493. A WATER MITE

The numerous radiating threads which have now been made are next united by a spiral one (the *first* spiral), the formation of which takes place from within outwards. This first spiral is then gradually removed and replaced by a *second* spiral, which is of sticky character, and serves to entangle the prey. It starts on the outside of the web, but does not reach the centre, where a piece of the first spiral is allowed to remain. It is here [496] that the ingenious weaver commonly stations herself and patiently awaits the expected booty. In some cases, however, she lurks in the vicinity of the web, and the vibrations of a special "signal line" enable her to tell when a victim has fallen into the toils. It must be added that the exigencies of the case usually involve more or less departure from the type described, especially in the outer part of the web [496].

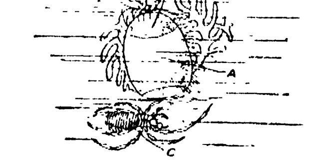


490. BEGINNING OF A GARDEN SPIDER'S WEB
a, b, c, d. Frame *e.* Vertical thread *f, g, h, k.* Radial threads *o.* Centre

The Legs of the Spider. The four legs of a spider do not all play the same part in the making of a web. The two first pairs are concerned with maintaining the proper distances between the threads as they are spun, while the last two pairs have to do with weaving the same, holding them clear till attachment points are reached, and then securing their fixation. When we further remember that the spider climbs over her web with ease and speed, and without doing it the least damage, we shall not be surprised to find that her feet are of peculiar construction. Each of them [491] bears a couple of comb-shaped climbing claws, extremely smooth so as to obviate



492. WEB OF HOUSE SPIDER (REDUCED)
a. Snare *b.* Lurking chamber *c.* Back door *d.* Sand grains

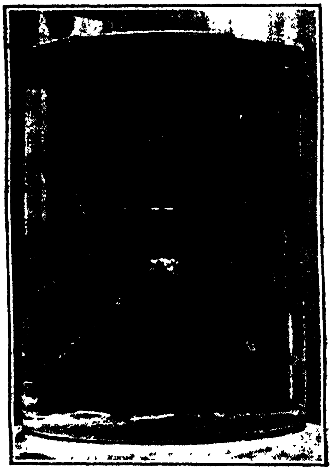


494. WATER SPIDER
a. Nest *b.* Eggs *c.* Spider with air-bubble

entanglement with the web. During the progression on earth or vegetation these are protected by a strong curved "walking claw." The toothed base of the latter helps in weaving, as does also a curious toothed bristle which is present.

Cobwebs. The webs of the common house spider (*Tegenaria domestica*), woven in some convenient corner [492], consist of a horizontal net, the actual snare, and a covered lair at the back of this, where the owner can wait unseen. The lair is provided with a back door or emergency exit. Grains of sand and similar substances are sometimes employed to weight down the web and keep it in proper position.

Gossamer. The floating lines of silk which drift through the air in spring and early autumn are often believed to be the work of a special kind of "gossamer spider." This, however, is not the case. They are spun by young spiders of various species to serve as means of dispersal. The little aeronaut commences operations by standing on some firm object, facing the wind, and spinning mooring-strands. The end of the abdomen is then turned up and a thread woven which streams out in the wind. When sufficiently long to support the weight of the spider the moorings are cut and the little creature is wafted away.



495. BIRD-SPIDER (REDUCED)

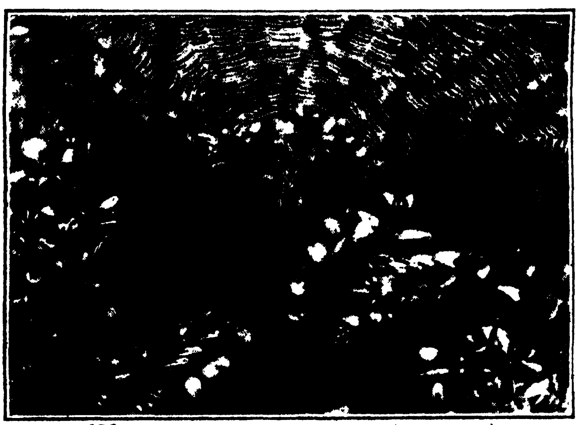
Water Spiders. Among the inhabitants of ponds and ditches in this country is to be found the water spider (*Argyroneta aquatica*), which hunts down small crustaceans but does not construct a web. For the protection of the eggs a thimble-shaped nest is woven [494], moored by threads to stems or leaves, and smeared externally with liquid silk to make it watertight. The nest is filled with air brought down from the surface of the pond in successive bubbles adhering to the hairy body of the spider.

Hunter Spiders. A great many species construct no webs, but use their silk merely for lining their dwellings—which are commonly underground—or the construction of protective investments for the eggs. Such forms simply stalk their prey, seizing the victims when near enough by a sudden spring. One such type is the tarantula spider (*Lycosa tarantula*), which was once supposed to be virulently poisonous. Violent and prolonged exercise was prescribed as the only means of cure, and the dance known as a "tarantella" seems to have been invented to promote this.

The clever trap-door spiders are widely distributed hunting spiders, noted for the neat way in which their underground dwellings are constructed. A cylindrical burrow is dug out and lined with silk tapestry, intruders being excluded by means of a circular door. This is made of particles of earth cemented together with silk, and provided with a strong hinge of the same material. A combined home, lurking-place, and nest is thus provided.

Bird-spiders. Some of the tropical species are of gigantic size compared with our native forms. Well known among them is the bird-spider (*Mygale avicularia*) of South America, the hairy body of which is little short of three inches in length [495]. Its prey consists of insects, other spiders, frogs, lizards, and even small birds.

Courtship and Mating. The male spider is relatively small and weak, while the female is apt to be savage, so much so that incautious advances on the part of a lover are not infrequently fatal to him. The body of the deceased furnishes light refreshment. In many species the male is beautifully coloured, and exhibits his charms to best advantage in the course of a weird sort of dance.



496. WEB OF GARDEN SPIDER (REDUCED)
(Photographs by Prof. B. H. Bentley)

Mites and Ticks. These are mostly of very small size, and all three regions of the body are fused together into an ovoid mass. Mites are terrestrial or aquatic [493]. Of the former the cheese-mite (*Tyroglyphus siro*) is the most familiar. Many are parasitic, some damaging cultivated plants, such as gooseberries and currants, others giving rise to certain diseases of animals, particularly itch and mange. Ticks are somewhat larger forms, which suck the blood of various mammals, and even attack human beings. They pierce the skin by means of their sharp proboscis, and only let go when gorged with food.

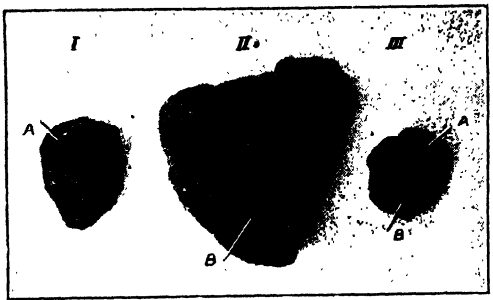
GILL BEARERS

King-crabs. These remarkable creatures live in shallow water on the western shores of the North Atlantic and Pacific, feeding chiefly upon marine worms. They are the last survivors of a waning group, and in some respects resemble arachnids, though they breathe by means of gills and are also allied to the crustaceans. The front part of the body (head and thorax) is covered with a strong, semi-circular shield [498], on the upper side of which the eyes are situated. This region bears six pairs of limbs, corresponding to the chelicerae, pedipalps, and walking-legs of a scorpion or spider. Their bases surround the elongated mouth, and are roughened to serve as jaws. The last pair are used for digging.

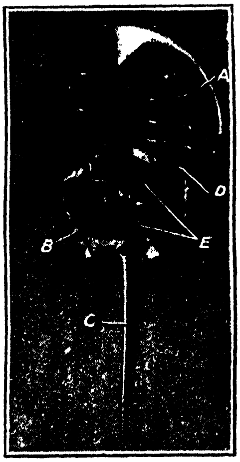
The rings making up the abdomen are also fused together, protected by a shield above, and bearing a tail-spine which serves to right the animal if accidentally turned on its back. There are plate-like abdominal limbs, on the upper surfaces of which delicate folds play the part of gills.

Eurypterids and Trilobites. These are two ancient groups of animals, long since extinct, but resembling the king-crabs in some respects. Many of the body rings were distinct. Some of the Eurypterids [505] were as much as 6 ft. long—for details see GEOLOGY.

Trilobites [497], which came into existence long before the Eurypterids, were mostly of small size, the largest species not exceeding a length of 1 ft. There were delicate feelers on the head, and numerous slender forked limbs, some of those in front being modified into jaws. Eyes, sometimes of great size and complexity, were usually present, but some species were blind. Certain kinds were able to roll themselves up like hedgehogs when alarmed.



497. TRILOBITES
a. Head shield *b.* Tail shield I has tail shield missing II has head shield missing III is rolled up



498. KING-CRAB
a. Shield *b.* Abdomen *c.* Tail-spine *d.* Digging leg *e.* Abdominal limbs

499. CRAYFISH
a. Head *b.* Thorax *c.* Abdomen *d.* Telson *e.* Small feeler *f.* Large feeler *g.* Side-piece of tail fin

500. SHIP BARNACLES (REDUCED)

Crustaceans. This large class of jointed-limbed animals includes lobsters, prawns, shrimps, crabs, and other familiar forms, the great bulk of which are aquatic, though the wood-lice have become adapted to a life on land. The body is clearly divided into rings, though those of the head are fused together, and this is more or less the case—in higher forms—for those which compose the thorax. Limbs are borne on all three regions of the body, and are typically forked, but in many instances the outer branch of the fork has been lost. The head bears two pairs of feelers. Crustaceans commonly hatch out as free-swimming larvae, more or less like the adult in form.

501. HERMIT CRAB AND SEA ANEMONES
(Photographs by Professor B. H. Bentley)

Higher Crustaceans. In these the body is made up of 20 rings; 5, 8, and 7 of which belong to head, thorax, and abdomen respectively. There are two large compound eyes, and the larval form is known as a *zoœa*, distinguished by the possession of a large shield covering the front part of the body, and a slender, limbless abdomen [503]. The group is divided into (*a*) stalk-eyed and (*b*) sessile-eyed forms.

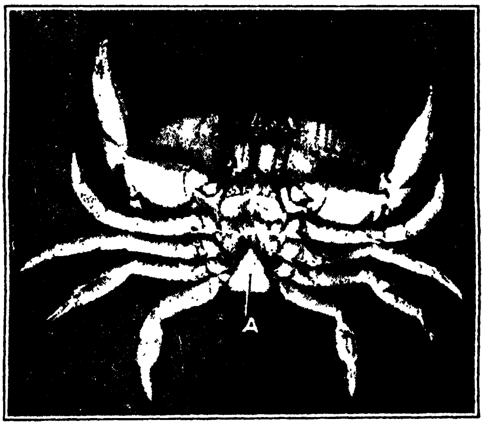
Stalk-eyed Crustaceans. The lobsters, crabs, etc., included in this subdivision possess a

strong shield or carapace, belonging to the head and thorax, all the rings of which are intimately united into a solid mass. The horny covering of the body is more or less strengthened by limy matter, so as to constitute a hard "crust," whence the name crustacean (Latin *crusta*, a crust). This is unable to increase in size as the body grows, and is therefore cast off or moulted periodically. The lack of mobility in the front part of the body that results from fusion is partly compensated by the stalked eyes, which can be moved about to a considerable extent. The members of the group are often known as the "ten-footed" crustaceans (*Decapoda*), because there are ten obvious limbs —the two great pincers and four pairs of walking-legs—all belonging to the thorax.

Large-tailed Decapods. These include lobsters, crayfishes, prawns, and shrimps, all marine except the crayfish, which lives in rivers. It will be convenient to take the last-named as a type [**499**]. The large tail consists of seven segments, all bearing appendages except the last (telson). These are forked paddles (swimmerets), which constantly swing to and fro, keeping up a current of water useful for breathing purposes; besides this they are used to some extent in swimming (especially in shrimps and prawns). The eggs of the female are attached to them, and are thus well protected up to the time of hatching.

The Swimmeret. A swimmeret [**507**] consists of a short stalk, an outer branch, and an inner branch. In those borne by the last segment but one the stalk is very stout, while the outer and inner branches are broadened into plates which, together with the telson, make up a powerful tail-fin. Swimming is effected by powerful downward movements of the tail (abdomen), during which the tail fin is spread out to its fullest extent. By this means the crayfish is propelled rapidly backwards. Every time the tail is straightened in readiness for a downward stroke, the tail fin folds up, so as to reduce the resistance of the water as much as possible. The front part of the body, covered by the carapace, is divided by a neck-groove into head and thorax. On either side of the latter is a chamber containing a number of plume-like gills. They are covered by the side of the carapace and thus protected from injury. The pincers and walking-legs borne by the last five segments of the thorax have lost the outer branch seen in the swimmerets. These are present, however, in the three pairs of *foot-jaws* [**508**] attached to the first three segments of the thorax and helping to break up the food. Some of the gills are attached to the thoracic appendages.

502. SWIMMING CRAB



503. EDIBLE CRAB *a.* Abdomen

Powerful Jaws. The last three of the five head segments bear *jaws* [**508**], named, from behind forwards, *second maxillæ*, *first maxillæ*, and *mandibles*. The last (which, like the first maxillæ, have lost the outer branch) are extremely powerful. An oval plate, the *baler*, is attached to the second maxilla, and lies in the front of the gill cavity. Its constant movements help to keep water moving over the gills. Jaws and foot-jaws alike move from side to side. These biting structures are supplemented by a complex chewing arrangement, or *gastric mill*, contained within the stomach. This is present in all the higher crustaceans.

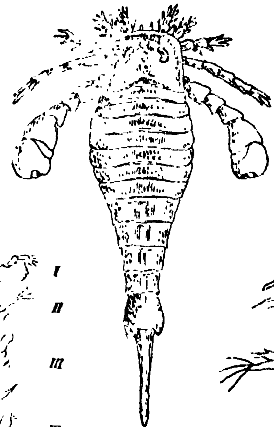
In front of the jaws are two pairs of forwardly-directed feelers (*antennæ*). The hinder pair are large and relatively long. They are chiefly concerned with touch, and constantly describe sweeping movements. The small first feelers are obviously forked, and have to do with both touch and smell, while an open sac is lodged in

504. SHORE CRAB WITH (A) SACCULINA ATTACHED
(Photographs by Professor B. H. Bentley)

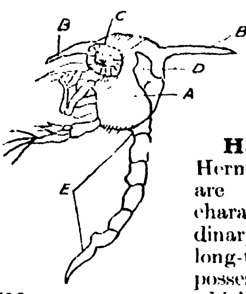
the base of each. Though this is often described as an organ of hearing, its chief, and perhaps its only, use is to assist in maintaining the balance of the body by acquainting the crayfish with its varying positions in space. The front end of the carapace tapers into a sharp spine, on either side of which is a deep notch occupied by the stalked eye.

Relatives of the Crayfish. The marine relatives of the crayfish hatch out as larvæ, but such an arrangement is unsuitable for life in rivers, for these would be unable to resist the current, by which they would be swept down to the sea to perish. The crayfish that is just hatched closely resembles the adult in appearance, and for some time holds on to a swimmeret by means of its sharp pincers. Even when somewhat further advanced it receives a share of maternal protection, sheltering under its mother's tail on the approach of danger.

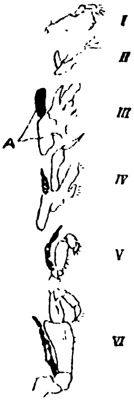
Among other long-tailed crustaceans the little Æsop prawn (*Hippolyte varians*) is of particular interest on account of the way in which it is able to change colour for protective purposes. A red, green, or brown livery is assumed, according to the hue of the seaweeds among which it lives. On the approach of night it changes to a beautiful blue, but the meaning of this "sunset" colouration is not fully understood. Some of the deep-sea prawns are blind, others possess enormous eyes, and many emit a phosphorescent light.



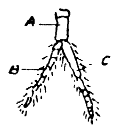
505. EURYPTERID



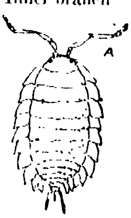
506. ZOAEA LARVA
a. Shield *b.* Spines in shield *c.* Eye *d.* Heart *e.* Abdomen



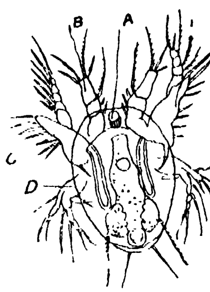
508. JAWS AND FOOT-JAWS OF CRAYFISH
I. Mandibles
II. & III. First and second maxillæ
IV., V., & VI. First, second and third foot-jaws. Outer branches are black
a. Baler



507. SWIMMERET
a. Stalk
b. Outer, and
c. Inner branch

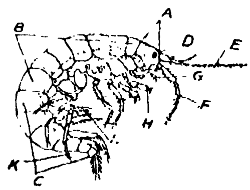


509. WOOD-LOUSE
a. Eye



510. NAUPLIUS LARVA
a. Unpaired eye *b.* First feelers *c.* Second feelers *d.* Mandibles

Short-tailed Decapods. These are the *Crabs* [502-4], in which a swimming habit has been abandoned for a creeping one. The head and thorax are enormously broadened out, while the insignificant and dwindled tail is tucked up on the under side of the body out of harm's way. All crustacea are scavengers, but the crabs are notoriously so. Some of them have taken once more to swimming, but not by means of the tail, which has been too much reduced to be again enlarged for the performance of its original function. The swimming organs are here the last pair of walking-legs, which have been broadened out into paddles [502].



511. SAND-HOPPER
a. Head and first ring of thorax *b.* Last seven rings of thorax *c.* Abdomen *d.* Eye *e.* First, and *f.* second feelers *g.* Foot-jaw. *h.* First, and *k.* last legs *l.* Abdominal limbs

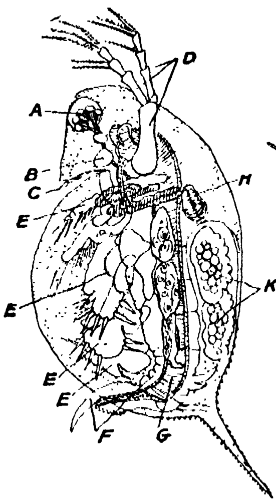
Protective Colouration. Most crabs are so coloured and marked as to resemble their surroundings, thus escaping to some extent from their numerous foes. Others are protected by a chevaux-de-frise of long, sharp spines. Others, again, make themselves inconspicuous by cultivating seaweeds or sponges on their backs. Sponges smell and taste unpleasantly, besides which they are full of sharp spicules; and hence, fishes and other enemies leave them alone. We also find a sort of comradeship between certain crabs and sea-anemones attached to their carapaces [see Plate facing page 4081]. The anemone gets carried about and, therefore, has a better chance of securing food, while its stinging powers go far to shield its messmate against attack.

Hermit Crabs. Hermit crabs, which are intermediate in character between ordinary crabs and the long-tailed lobster tribe, possess rather long tails, which are, however, quite soft and defenceless. To make up for this the empty shell of a sea-snail is used as a covering. Upon this shell one or more sea-anemones are usually found as messmates [501]. From time to time a new and larger shell has to be appropriated, to which the hermit crab is said to transfer his guardian anemones.

Sessile-eyed Crustaceans. These are much smaller than the stalk-eyed forms, and only the front ring of the thorax is fused with the head. There is but a single pair of foot-jaws, and the eggs are sheltered in a brood-chamber on the under side of the thorax. The eyes are devoid of stalks, giving origin to the name *sessile*. The group includes (*a*) sand-hoppers and their allies, and (*b*) slaters. The *sand-hoppers* and their allies are distinguished by the strongly bent body, which is greatly flattened from side to side [511]. This not only promotes swimming, but also springing, the latter movement being particularly obvious in the common sand-hopper (*Talitrus*),

which lives in vast numbers between tide-marks on sandy shores.

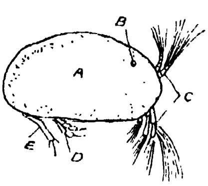
Slaters are creeping forms with the body greatly flattened from above downwards. This is an adaptation to life in chinks and crevices. Sea-slaters are common on rocky coasts, but the most familiar crustacean of the kind is the land-slater or wood-louse (*Oniscus*) [509], common under stones and in the crannies of old masonry. An allied form protects itself by rolling up. The water-slater or water wood-louse (*Asellus*) is a common inhabitant of our ponds, but its numbers are kept down by many enemies, of which the water-spider is one of the most formidable.



512. WATER-FLEA
a. Compound eye *b.* Brain *c.* First feeler *d.* Second feeler *e.* Thoracic limbs *f.* Abdomen *g.* Intestine *h.* Heart *k.* Embryos in brood-pouch

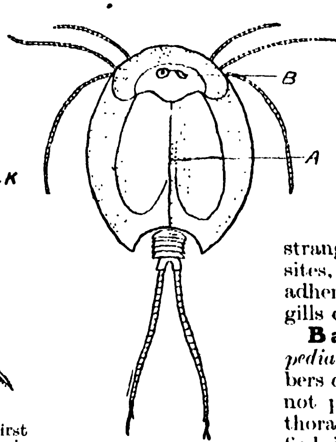
Lower Crustaceans. These are generally small or even minute creatures, presenting considerable variation as to the number of the rings and the character of the appendages. They commonly hatch out in the form of an oval *nauplius* larva [510] which rows itself about by means of the feelers and mandibles, the only appendages present at this stage. There is a simple unpaired eye.

Gill - footed Crustaceans (*Branchiopoda*). These forms are so named because their flattened limbs are used for breathing purposes and bear the gills when these are present. One of the largest and most interesting types, Apus [513], lives in stagnant water, and possesses a large head shield which covers the chief part of the body. It rows itself along on its back by means of the numerous leaf-like appendages, to which soft, pear-shaped gills are attached. Much more specialised are the water-fleas, one kind of which (*Daphnia*) [512] abounds in ponds, and is a very attractive object for the microscope. The tail is greatly reduced, and most of the body is enclosed in a large bivalve shield. The enormous second feelers are used as oars. Between the shell and upper side of the body is a space used as a brood-pouch. Mussel-shrimps (*Ostracoda*) are small forms which swarm in both salt and fresh water. The tail is reduced to an insignificant stump, as in water-fleas, and the whole of the body is enclosed in a strong bivalve shell [514].



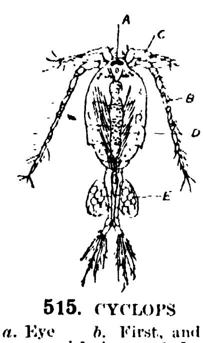
514. MUSSEL-SHRIMP
a. Shell *b.* Eye (shining through) *c.* Feelers *d.* Legs *e.* Abdomen

Fork-footed Crustaceans (*Copepoda*). These minute creatures live in vast shoals at the surface of both salt and fresh water, and receive their name from the shape of most of their appendages. The female of a common freshwater species (*Cyclops*) is here figured, carrying her pair of egg-bags [515]. The feelers are the chief swimming organs. The members of this group are of great economic importance, for they figure largely in the food of fishes, such as, for example, the herring. Many of them are strangely modified parasites, which may be found adhering to the skin or gills of fishes.



513. APUS
a. Shield *b.* Eye

Barnacles (*Cirripedia*). In those members of this group that are not parasitic most of the thoracic limbs are modified into long, hairy filaments, used as a sweep-net to produce food. The tail is reduced and the body fixed by its head end to some firm object, as well seen in the ship-barnacle (*Lepas*) [500], and the acorn-barnacle (*Balanus*) which abounds on rocks between tide-marks. In both cases the body is protected by shelly plates, but the head-end of a ship-barnacle is drawn out into a long, fleshy stalk.



515. CYCLOPS
a. Eye *b.* First, and *c.* second feelers. *d.* Intestine *e.* Egg-bags

Many creatures of the barnacle kind are degenerate parasites, a remarkable example being afforded by a form known as *Sacculina*, of which the adult female will be found attached to the under side of a crab's tail [504]. Dissection shows that this is provided with branching root-like threads, which ramify within the body of the unfortunate host, extending even into the tips of its legs. These absorb the blood of the crab to serve as nourishment for the parasite, which is little more than an egg-producing arrangement. The life history, however, proves that Sacculina really belongs to the lower crustacea, for it hatches out as a typical nauplius larva.

Continued

Group 19 JOURNALISM 1 Following upon LITERATURE from page 3783	# JOURNALISM, THE IDEAL CAREER The Fascination and Power of Journalism. The Character of the Journalist. Sincerity a Decisive Factor. The Sense of Wonder

By ARTHUR MEE

THERE is a calling that makes a man a king. The man who, having a thought, has discovered the secret of spreading his thought throughout the world, is a king among men. To this royal line belong Plato and Shakespeare and Herbert Spencer, and a great host whose names would make a longer list than those of lesser kings and queens whose names we learnt at school. All civilised countries, says Carlyle, are governed by books.

The Democracy of Journalism. At the gates of the kingdom of letters lies the broad field of journalism. Here, at his will, with no sceptre but a pencil, with no authority but his intellect, with no force but that of character, a man may sit and earn his bread and rule the world. No career that is open to man can compare with it. No career can place a man so quickly on the very heights of power, can invest a man so simply with all the possibilities of fame. Journalism is the most truly democratic of all callings. It is open to all, yet on the roll of its followers we come continually across the names of poets and statesmen and the very elect of the earth.

It has been a greater power in the world than any mechanical force controlled by man; it has controlled those forces. In the history of mankind newspapers have been stronger than armies. Napoleon feared four hostile papers more than a thousand bayonets—"a regent of sovereigns, a tutor of kings," he said of the journalist.

The Power of the Journalist. And, in truth, it is no exaggeration to say that the power of the journalist cannot be exaggerated. If he cannot make laws, he makes the lawmakers. He is the silent force in every Parliament, the unseen factor in every polling booth. He is present, invisible, in every Cabinet. Not a prince upon his throne, not a draper behind his counter, is beyond his reach or outside his interest. He has, by right of mind alone, the open sesame to every place. No door is locked to him; even those doors most jealously guarded are open, though the public knows it not, to the journalist who can keep a secret better than he can tell it. He is everywhere, always. Nothing happens that he has not seen; there is no corner of the world to which he has not been. He has the master key of government—at his command is the only vehicle in the world by which one man can communicate instantly with all other men. He can make wars and bring peace; he can make revolutions and destroy them. He has more power in the market than the Stock Exchange. Even the scales of legal justice may be subject to his will.

Without him life as we know it would be impossible. He stands between light and darkness, between social peace and civil war, between democracy and despotism, between the freedom of the twentieth century and the inquisition of the Middle Ages. He is the guardian of the liberties of the human race.

Well may the journalist be proud of his calling. To him who cannot be a statesman or a king, or who finds the golden gateway of letters closed to him, journalism offers a power and joy of life which perhaps nothing else can give. One man may find a country hitherto unknown, another may discover a new source of energy, the astronomer may discern a new star, the chemist may reveal new marvels in creation, the engineer may span a great gulf with steel or save the time of the world by cutting a great canal; but there can be nothing in these things, momentous as they may be to the world, comparable with the shaping of the world's thought which is the power of journalism.

The Reflector of Human Life. Neither exploration nor engineering, no kind of business, none of the professions, not science itself, can give a man so wide an interest in life as journalism. The astronomer reading the stars, the engineer constructing a waterway, are interested in their own achievements, but not necessarily in each other's. It has nothing to do with the engineer that the organic world would come to a standstill if chlorophyl could be destroyed; the chemist in his laboratory is unconcerned that the voyage to India has been shortened by ten days through a great canal. Neither is *necessarily* interested in the work of the other. It is the glory of journalism that the journalist is, *must be*, interested in both.

Since journalism is the reflector of human life, nothing in human life can happen that is outside its scope. As memory, whether we will or not, engraves upon itself the everlasting remembrance of everything we see, or hear, or do, or know, so journalism brings all life, all activities, all thought, all labour, into its boundless field. Nothing is too trifling for its interest, nothing can be too important for its debate. The analogy, indeed, may go farther, and become exact. As the mind edits the memory, calling up at will those things which interest it, whether facts, or scenes, or men, or things, whether they have been treasured there 50 years or only 50 hours, so the mind of the journalist edits the happenings of every day and every hour, lays them out upon his sheet before him, appreciates this, questions that, casts aside the other, and presents his picture to the waiting world with a judgment born of an intimate relation with

men and a knowledge of the relative values of things.

A Daily Record of Good and Evil. The whole world is alive to the journalist who knows his work and is in earnest. The well-edited newspaper has no "dull" season. Until the world is a dead place, until men cease to think and roses cease to smell sweet, life can never be dull to the journalist worthy of the name. What, indeed, could be more full of tragic interest than the very despair of a man whose business it is to watch and interpret the ceaseless panorama of human life who wakes up in the morning to see the panorama passing before him, but finds that "there is nothing to write about to-day"?

It can hardly be too strongly insisted upon that the business of the journalist is to give to the world a living record of its own life. It is, no doubt, to be insisted upon as strongly that there are things with which the journalist has no business; but, on the whole, the editors know their business a great deal better than the critics who would teach them. It can never be admitted that the journalist should give only the better side of things. Those mistaken advocates of a journalism which would whitewash the world, of newspapers which would fill our minds with only pleasant things, have never surely thought for an hour of what would happen if they had their way.

Let them imagine a patient who hides his symptoms from the doctor, a witness who keeps back vital evidence from the judge. If the power of journalism is anything but a phrase, it depends chiefly or entirely upon its unique capacity for the exposure of wrong, the denunciation of tyranny and injustice. Could we ever hope that the world will one day be free from the curse of drink, if it were not that its trail of sin and ruin runs across every paper we pick up? Could we ever hope that the poor will one day be better housed, if it were not that every paper in the land is filled with pictures of the wretchedness of their lives?

Should an Editor Lose His Temper? Let us remember, in making up our minds to be journalists, that a simple picture of something that exists is sometimes the most powerful agent in improvement that could be devised. There are times, no doubt, when good men feel that journalism oversteps its bounds, when good men would welcome for an hour a censorship of the Press. But only for an hour. And, after all, it is still true in these times that the newspapers reflect the nation. Shall we, then, censor a nation?

"Is it not, then," the young journalist may ask, "the greatest tribute that can be paid to the newspapers to say that they reflect the nation in its hot temper as well as in calm, in its worthiest and least worthy moods?"

That would be so if there did not enter into our consideration here a vital function of journalism which the true journalist can never overlook. It may be held, no doubt, that the entire business of the journalist is to hold a mirror up to nature and reveal the world unto itself. That, once upon a time, was true in practice; in theory it is admirable still. Nothing could be better for an ideal world.

But there has grown up in the development of civilised societies a mysterious and wonderful factor, with the full authority of a judge but without the limits of a court, sitting in judgment over the good and evil of society at large. It is the newspaper editor.

And, just as a judge, though the system of justice he administers reflects the average sense of justice in the nation, is still calm and unmoved by the excitement in the streets outside, so the editor, though his paper reflects the average mind of his reader, should be unmoved by the wild temper of the mob and calm amid the dangerous excitements of the hour. Who claims the right to sit in judgment must prove himself fit to be a judge.

It is one of the misfortunes of journalism as a profession that it attracts to itself men who enter upon it as a career without an adequate sense of its importance or a serious consideration of their fitness for it. The very democracy of journalism, which is one of its finest characteristics, is in some senses a drawback. Open to all, demanding no tools but a pencil and a notebook, with pleasant prospects and "quick returns," it is not surprising that the newspaper offices are besieged, and that the number of people who would gain a livelihood by writing for magazines is ever increasing.

Character and Learning. At the very outset of our course let us emphasise for ourselves a truth of the utmost importance.

The road to success in journalism is as free as the air we breathe, and we need have no sympathy with any attempt to make journalism a close profession—a profession, that is, which can be entered only through a particular door, under particular conditions. It is as impossible as perpetual motion, and we need not consider it.

But it does not follow from this that there is no need to guard the gates of journalism, as the gates of medicine, of law, of banking are guarded—though not by the same means or for the same reason. There is no way of closing the door of journalism against a man who has not passed an examination. Such a rule as that, if any means existed of enforcing it, would have made it impossible for Herbert Spencer to be a journalist, for Herbert Spencer never passed an examination. A journalist without education is, of course, a contradiction in terms, but education is not the only, not even the chief, bulwark of journalism. It is not *learning* but *character* that should be the decisive factor in the choice of journalism as a profession, and it is a thousand pities that men should enter upon a career so full of responsibility, so fraught with possibility, without realising that journalism is something more than a wage-earning career. The surgeon who would perform an operation solely for his fee, without any regard to the value of life, and the journalist who writes purely for his pay, without any regard to the effect of his

writing, belong to the same category of men who are unworthy of their profession.

The Two Kinds of Journalism. It does not follow, of course, that a journalist must have settled convictions about everything on which he writes. That cannot be, nor is it necessary. Journalism is of two kinds—the kind that *interests* and the kind that *influences.* We may compare them with a public meeting called together in support of a particular cause, and a lecture by, say, Mark Twain, whose business it is only to entertain.

It would be impossible to defend a speaker at a public meeting who moved a resolution in favour of a cause to which he was in his heart opposed, but Mark Twain need not be called upon to defend anything he may choose to do or say in entertaining his audience. We do not ask Mr. Pett Ridge to substantiate his statements, or whether he really believes in them, and, happily, the vast majority of journalists are in the same position. It is not necessary for them to perjure their conscience, or to sink in the esteem of sincere men, by writing what they do not believe.

There is another side to journalism, however—a journalism which shapes opinion; and here it cannot be too emphatically said that the first of all considerations is sincerity. The journalist who cares for the honour of his calling cannot have too great a contempt for the man who brings his mind but not his soul into work which should engage his deepest feelings and enlist his warmest sympathies. There are hundreds of men, it is true, who make a living to-day by writing in absolute contradiction of what they wrote yesterday, and who will make a living to-morrow in denying what they wrote to-day. But we need not call them journalists. We could much more correctly describe them as men who will sell their souls to anybody who will pay for them, or, in the slang of the profession, penny-a-liners, or sixpence-a-liners, according to the profit their empty phrases bring them.

We may have opportunities of discussing this matter again; but to the candidate for journalism it may be said here that the man who will write anything he is paid to write never rises high in his profession. The great names in journalism are those of men who wrote finely because they felt deeply, who wrote interestingly because they thought earnestly.

Factors in the Journalist's Success. It is not an exacting demand that journalism makes upon those who would enter its ranks. The man who brings to it a clear head, plenty of common sense, good judgment, a sense of the relative importance of things, an average experience of the world, a capacity for interesting himself in anything and of expressing himself plainly, is likely to succeed.

He must have many other things, of course, which we shall have to consider in their place. He must never, for example, admit to himself that the age of wonder is past. A sense of wonder—with something in it of the surprise of the little child that the stars do not fall from the sky, with something of the terror of the child at the approach of an express train—is a gift for which a journalist can never be grateful enough.

Is it a commonplace thing to you that from three seeds should come in one place a violet, in another a wallflower, in another a turnip? Can you take down the telephone or send off a telegram without feeling that you are touching a miracle? Can you stand in a country lane at night watching a well-lighted train flying through space with a thousand lives without feeling that here is something of the majesty of man and the supremacy of mind? Are these things nothing to you? Then there may be somewhere in journalism a bushel under which you can sit and hide the little glimmering of light that may come from your mind; but you will not do great things. You will not interest a vast public in the things that happen day by day. You will not take up a book and make it live. You will not think of a great idea and stamp it on the minds of your fellow-men. You will not carry your reader into a world of imagination where you can do with him as you will.

You will find that the world prefers somebody else's poetry to your prose, and you will wish, when it is too late, that you had earned your bread at something wanting less of the wonder of a little child than journalism.

The Journalist at Home. One other aspect of journalism may be touched upon here. The journalist leads "the intense life that eats into the souls of men," and one point may be insisted upon as of great practical importance to the candidate for this strenuous career. It is his domestic atmosphere. If it is the attraction of journalism that all life comes into it, it is also its great temptation. For, obviously, if all that happens comes into his work, nothing that happens will take him away from his work. The power of detachment, the capacity for putting things out of his mind, is of the greatest value to him, and no means of reaching this happy state of being is so easy and so simple as sympathy at home. Congenial friends, sympathetic interests, pleasurable associations, are half of life to us all, but to the journalist wrapped up in his work they are much more than half the secret of a happy life. The accountant goes home from his office leaving the world of figures behind. The merchant finds at home a welcome pause from the stress of business. The shopkeeper puts his work out of his life when he puts up his shutters. The journalist takes his work home, for his work is life itself.

Of profound importance to him, therefore, are the atmosphere in which he lives and moves and the hours which belong to himself, when, if ever, he may be encouraged to detach himself from the things that possess him, to change his mental vision, to find fresh stimulus in the affections and pleasures of home.

Continued

MOUNTAIN RAILWAYS

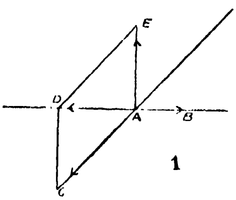
The Rack-and-pinion System. Examples of Mountain Railways. Racks, Locomotives, Points, and Switches. Sphere of Rack Railway

RAILWAY CONSTRUCTION continued from page 3752

By C. O. BURGE, M.Inst.C.E.

RACK-and-pinion railways have been devised to overcome the difficulties arising from the slipping of the engine wheels when excessively steep gradients have to be negotiated in mountainous districts, and are therefore much used in Switzerland and similar countries for tourist and other traffic. To understand the necessity for some such contrivance as a rack-and-pinion arrangement, which adds considerably to the cost and maintenance of a line, the following law of physics must be recognised.

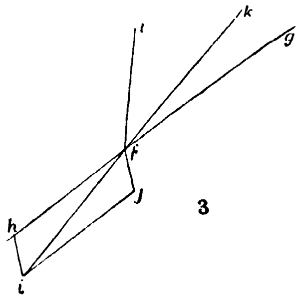
If on a fixed horizontal plate of smooth steel a steel rod be pressed vertically, no action will take place; but if the top of the rod be gradually inclined, with the pressure continued, until a certain angle between the rod and plate is reached, the point of the rod touching the plate will slip. This angle is called the *angle of repose* or *friction*, and it differs according to the nature of the materials in contact. In this position [1] the friction, represented by A B, is insufficient to counteract the resultant A D [see MECHANICAL ENGINEERING, page 411] of the pressure A C, and its reaction A E.



1

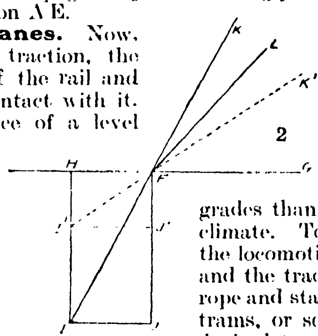
Weights on Inclined Planes. Now, let us apply this to railway traction, the smooth plate being the surface of the rail and the rod being the wheel at its contact with it. Let H G [2] represent the surface of a level railway. Let the length F J represent the weight on the driving wheel of an engine, and F H the force which it is able to exert—that is to say, the pressure—in the direction F H, at the circumference of the wheel, which, if resisted by friction at F, represents the tractive force drawing the train, including the engine, in the direction F G. The resultant of the pressure of gravity, F J, and the resistance, F H, of the train is F I, which, produced towards K, makes an angle G F K with the rail H G. Now, let G F L be the angle of friction of steel on steel. It is evident, therefore, that if this angle be less than G F K, the steel of the wheel will not slip on the steel of the rail, and the force of the engine, exerted against the surface of the rail at F, will be utilised in drawing the train in the direction F G.

Two conditions may vary the angle G F K and destroy this result. First, the weight F J on the driving wheel may be reduced to, say, F J′, when the angle G F K′ will be less than G F L, and the engine will become powerless through the wheel slipping; and, secondly, the railway may be on such an incline as in *h g* [3], when the resistance of gravity is added to such an extent to the ordinary resistance of the train that the resultant *f i*, produced towards *k*, forms a smaller angle with *hg* than the angle of friction *g f l*, and the engine loses its hold, or *purchase*, as it is called. Hence, given the weight on the driving wheel and that of the train, there is a limit to the grades on which ordinary adhesion suffices. By multiplying the driving wheels by coupling them, and by the locomotive carrying its own supply of water with it, in the form of what is called a *tank* engine, so that more of its weight may be utilised on the drivers, and *f j* and the angle *g f k* increased accordingly, the limiting grade may be extended.



3

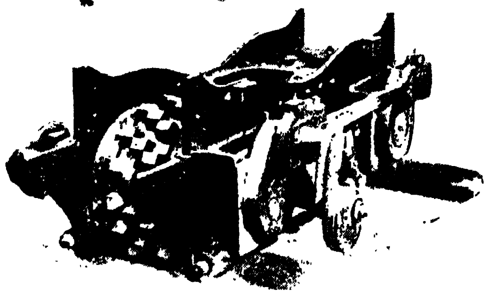
Locomotive Power on an Incline. The angle of friction of steel on steel varies with the weather, the greasy state of the rails affecting it; but, ordinarily, an engine, even with all wheels coupled, can seldom take any reasonable load beyond its own weight up steeper grades than 1 in 15 to 1 in 20, according to climate. To overcome such inclines, either the locomotive must be abandoned altogether and the tractive force supplied by means of a rope and stationary engine, such as in the cable trams, or some special contrivance must be devised to enable the locomotive to retain its hold on the rails. Such a special contrivance is the rack and pinion.



2

The Rack and Pinion. This invention of the rack and pinion is almost contemporaneous with the introduction of the locomotive. Trevethick's engine of 1804, owing to its lightness as well as its want of power, could not do much more than draw itself. Blenkinsop, in 1811, not seeing that additional weight would overcome the want of adhesion, provided the rail with teeth, and the driving wheel itself was the pinion, and by this his 5-ton engine succeeded in drawing 90 tons at 4 miles per hour on the level, and 15 tons up 1 in 20.

George Stephenson, however, with his keen insight, perceived that as the great additional power which he foresaw as inevitable would, with its heavier boiler, cylinders, and all parts, provide sufficient weight for adhesion, reverted



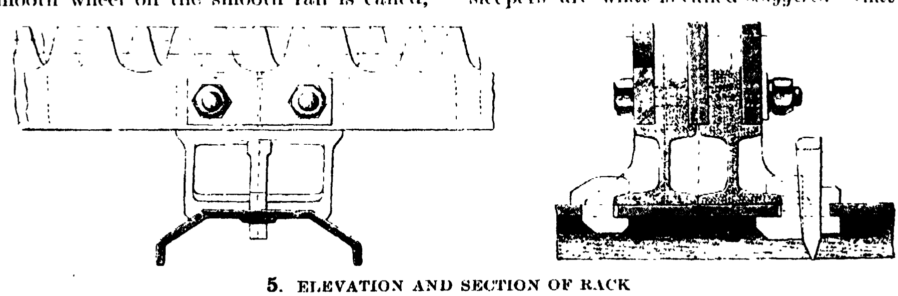
4. ENGINE PINIONS

to the simpler plan of the smooth rail, and subsequent designers increased it by coupling the wheels. The advance of railways necessitating steep grades revived the idea of Blenkinsop, and Cathcart, in 1847, devised a rack line in America, but placed it between the rails with a special pinion worked by the engine, the outer rails and wheels merely bearing the load, and all subsequent improvements have been based on this principle.

The next development was by Silvester Marsh, in 1858, in America, and by Riggenbach, in Europe, in 1871. In these an apparatus of ladder-like form was fixed in the centre between the rails, on the rungs of which corresponding protuberances on a centrally driven wheel acted. The Mount Washington line on Marsh's plan, and the Righi [**6**], the Wengern Alp, Brunig, Appenzel, and others in Europe on the Riggenbach system are examples. Roman Abt, however, who might be called the George Stephenson of the rack railway, introduced, in 1882, the system called by his name and now almost universally followed. Fig. **7** shows a portion of the Zermatt railway on the Abt system.

Present Day Practice. In the Abt system the ordinary adhesion principle, as the smooth wheel on the smooth rail is called, and the rack-and-pinion system are combined in one engine, one pair of cylinders working the driving wheels on the ordinary smooth rails, which carry the weight, and another pair actuating the pinions [**4**], which engage with the rack between the rails. By this method, when the train is on the level or on an easy graded part of the line where there is no rack, the pinion engine is stopped, the adhesion one doing all the work; but when the steep rack portion is reached, the whole power of both engines is put into action. It may be asked, How can adhesion help in this case? But it must be remembered that the boundary between the grading on which adhesion alone is sufficient and that on which it fails is very indeterminate, depending on two factors—the condition of the rails and the load to be drawn. For example, on a fairly steep grade an engine may be able to draw itself up by simple adhesion, but fail to draw a load behind it in addition, and to the former extent the rack mechanism of the engine is relieved of its work. It has also been found by experience that, should the adhesion driving wheel be inclined to slip, the action of the pinion and rack not only prevents any running back, which would increase the tendency, but by impelling the engine forward causes the adhesion wheel to bite on a new place, and thus regain its purchase.

A German Mountain Railway. The Hartz Mountain railway, in Germany, which has a heavy goods and passenger traffic, is one of the most notable examples of the Abt system, and, with some slight modifications, a description of it will serve for all. The line, though making a considerable aggregate ascent, is uneven, having many comparatively easy grades in its length of 19 miles, $4\frac{3}{4}$ miles made up of several separate short lengths being provided with the rack. The steepest grade on the adhesion part is 1 in 40, and on the rack portion 1 in 16·67, the sharpest curves being 9 chains and $12\frac{1}{2}$ chains radius on each respectively. The permanent way, which is on the standard gauge, 4 ft. $8\frac{1}{2}$ in., consists of steel rails weighing $60\frac{1}{2}$ lb. per yard, laid on steel sleepers of about 90 lb. weight each and 2 ft. $10\frac{3}{4}$ in. apart from centre to centre. The rack is of three steel bars, each 4·33 in. deep and 0·79 in. thick, and these are separated from each other by a distance of 1·36 in. The rack bars, which are suitably fixed to the steel sleepers are what is called *staggered*—that is to say, the teeth on one bar are not opposite to those on the one next to it, but are one-third of a tooth space in advance of them. In the pitch-line the teeth and spaces on each bar measure 2·36 in. [**5**]. The top of the rack is $2\frac{1}{4}$ in. over the rail level.



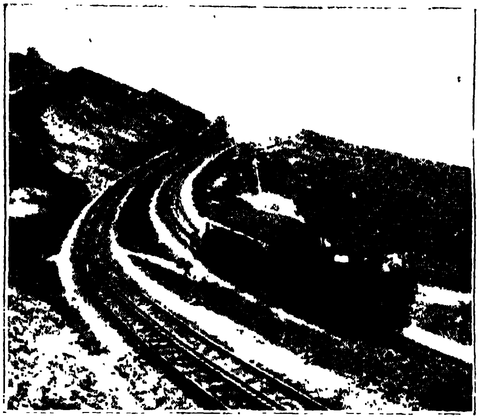
5. ELEVATION AND SECTION OF RACK

With regard to the pinions on the engine, there are two sets, one behind the other, each consisting of three discs at the same distance apart, 1·36 in., as that of the rack-bars, so as to engage with the latter. Their teeth are also staggered in such a manner that fresh cogs are being continually engaged, and there are always nine teeth in contact with the rack. By this arrangement [4] great smoothness in running is attained.

Entering the Rack. The transitions from the adhesion to the rack portions are not confined to where stoppages at stations occur, hence a device is necessary so that the engine, with its train, can run on easily from the former to the latter, without stopping.

The entry on the rack is by means of a straight triple rack-tongue [8], about 10 ft. long, supported on pairs of volute springs, based on a longitudinal sleeper in a pit, so as to admit of the vertical depression of the tongue if the teeth of the pinions should not engage perfectly on approach, and ride upon the teeth of the tongue-rack. The tongue is hinged at the end where it joins with the ordinary rack, and is tapered, as to its depth, at the other end, so as to facilitate the entry.

The steam is shut off from the pinion machinery on those lengths where the rack is not laid; but when approaching it the regulator of the pinion machinery is slightly opened so as to cause the pinions to revolve slowly, and enable them, as they ride on to the tongue, to engage the teeth of the tongue-rack without concussion. As soon as this is effected the regulator is fully opened, when the pinions take their fair share of the work in the ascent. As the engine is placed at the rear of the train in the ascent, the rack extends on to the adjoining lower adhesion length to the maximum length of the train, as otherwise the engine would not get the help of the rack when a portion of its train ahead is on the incline. Similarly, the rack is extended to some distance beyond the top of the incline, so that the engine, which leads in the descent, may have its pinions safely geared into the rack before the actual descent is begun.



6. RIGHI MOUNTAIN RAILWAY

The Locomotives. The engines are of the tank type, working without turning. The three axles of the adhesion wheels, 4 ft. 1½ in. in diameter, which are in front of the firebox, are coupled. In addition there is a fourth pair of wheels on a Bissel truck under the footplate. The pair of cylinders working the adhesion drivers is outside; those driving the pinions are inside. Each pair has separate steam-pipes from the same boiler, and has independent action. The two sets of pinions, which are 22·56 in. in diameter, are coupled, the rear one being the driver.

The toothed gearing is supported by an entirely separate frame resting on the leading and trailing driving axles of the adhesion wheels, so that the grip of the pinions is in no way affected by the play of the springs, and this inside frame is lifted from time to time to allow for the wear of the adhesion-wheel tyres.

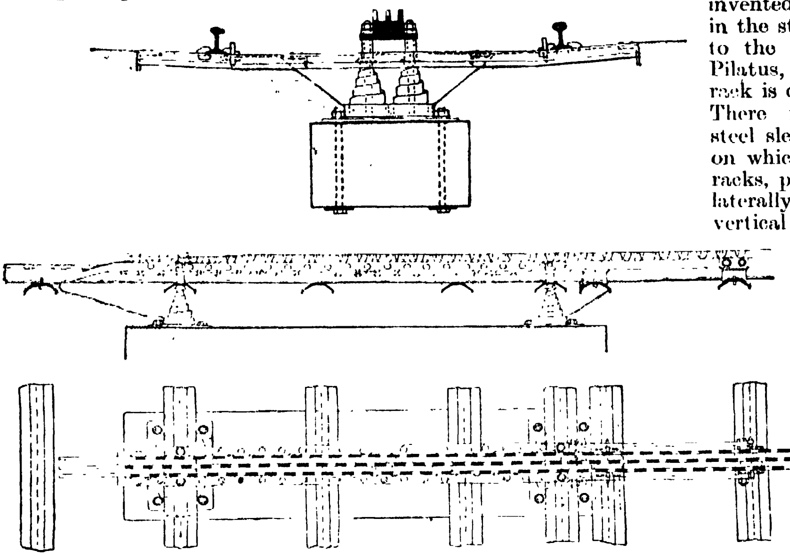
The total weight of the engine in working order is 55 tons, and the maximum gross load behind the engine is 137 tons. The ordinary load, however, is much less, and the coal consumption is about 50 lb. per train mile.

The wear of the pinion teeth, of course, is much greater than that of the rack-bar teeth, as each one of the former has a contact for every revolution, while each of the latter has only two contacts for the passage of each train. The pinion discs are taken off from time to time and reversed, so that each side of the teeth may wear evenly.

7. ZERMATT RAILWAY ON THE ABT SYSTEM.

Brakes and Points. There are four brakes on the engine, two hand-brakes, one acting on the tyres of the wheels in the ordinary way, and the other on grooved discs on each of the pinion shafts, which latter are, of course, effective only on the rack lengths. The other two are compressed-air brakes, one

acting on the adhesion mechanism, and the other on the pinions, and they operate by preventing the free escape of the air from the cylinders, thus using the compressed air in retarding the progress of the engine. The two hand-brakes are used for shunting purposes, while the latter two are for the descent. By the Government regulations, half of the vehicles besides the above must be provided with brakes, but these are not required, as a rule, to control the train, the engine brakes being sufficient.



8. PLAN, ELEVATION, AND SECTION OF RACK TONGUE

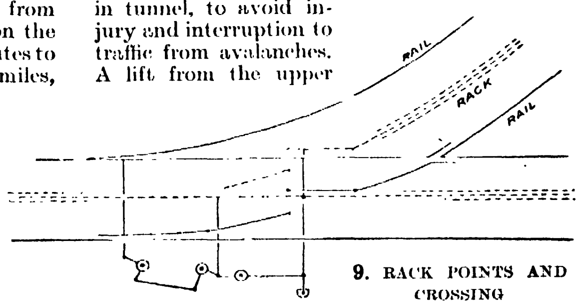
On the Hartz line there are no points and crossings on the rack length, hence these are of the ordinary description, but on other Abt rack lines they are made of the type shown in 9, which fully explains the movement of the switches of the rack in harmony with those of the bearing rails, the rack being here reduced for simplicity to a single bar.

Speed. As to speed, the trains take from 1 hour 56 minutes to 2 hours 20 minutes on the ascending journey, and from 1 hour 44 minutes to 2 hours 29 minutes descending, to do the 19 miles, the ordinary speed on the rack being about 4 miles per hour. On the Nilghiri Abt line in India a much higher speed is attained on the rack. The traffic is comparatively heavy on the Hartz railway, and on many of the 42 lines on different gauges in all parts of the world which now exist on the Abt system two rack-bars are found to be sufficient. Having the racks and pinions duplicated or triplicated, as in the Abt system, affords a good guarantee of safety in case of the breakage of a tooth. In fact, such a thing is not known to have happened.

Steel sleepers are generally used in order that, through their stiffness, the relative levels of the rail and rack should be well maintained; but on the Nilghiri line in India, and in other places where good hardwood timber is easily procurable, the latter is found to be sufficient. There are several Abt lines in which the grade is as steep as 1 in 4.

Other Systems. In the "Locher" system, invented in 1885, and used in the steep tourist line up to the summit of Mount Pilatus, in Switzerland, the rack is of a different form. There is a longitudinal steel sleeper in the centre on which is mounted two racks, projecting outwards laterally from a central vertical rib. The pinions of the locomotive, which are in horizontal pairs, engage with these, gripping the rack between them. The maximum grade is as much as 1 in 2·08.

The Strub rack, invented in 1896, reverts to the vertical type. It is being used on the Jungfrau metre gauge electric line, and is of very heavy construction. It was considered that, as so much of this railway was situated at a great elevation above the snow line, and was difficult of access for maintenance, a special heavy form of rack was required, and also on account of the severity of the grade, much of it being as steep as 1 in 4. As only about 100 days of summer tourist traffic in the year were available for working, heavy loads for such a grade were, therefore, to be expected as concentrated within that period, and a strong rack was consequently necessary. The line is about 7½ miles long, and the greater portion of the upper part is placed underground in tunnel, to avoid injury and interruption to traffic from avalanches. A lift from the upper terminus, which is underground at 13,425 ft. above sea-level, will take the passengers to the summit of the mountain.



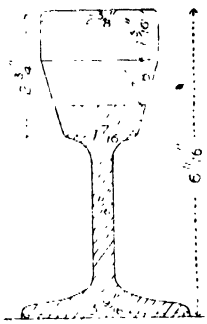
9. RACK POINTS AND CROSSING

Details of the Strub Rack. The rack, which is single, is fixed centrally on heavy hollow steel sleepers 5·91 ft. long, $9\frac{3}{16}$ in. wide, and $2\frac{15}{16}$ in. deep, 3 ft. $3\frac{3}{8}$ in. apart, centre to

centre, and weighing 81·57 lb. each. The rack [**10 and 11**] is $6\frac{1}{16}$ in. deep, and $2\frac{3}{8}$ in. wide at the top, narrowing downwards to suit the grip brakes employed. Its tensile strength is 28·57 tons per square inch, and it weighs 68·55 lb. per yard.

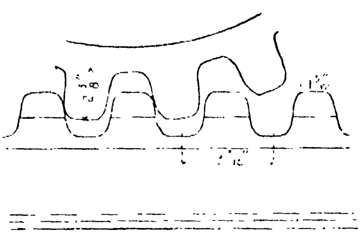
The train is composed of a compound vehicle comprising an electric motor carrying 30 passengers, and another car with 50 passengers, the whole weighing about 26 tons. The motor, as well as the electric installation of this line, is referred to in courses of Electricity.

The brakes are of the shape of a forceps, worked by hand from the floor of the vehicles, and their action can be fully understood from **12.** When not closed on to the rack for actual braking, the jaws of the brake project under the head of the rack so as to prevent derailment should the vehicle tend to rise from any obstruction on the line or other cause. They also prevent the side-slipping of the pinion.



10. SECTION OF STRUB RACK

In the excessively steep lines, it is found necessary to anchor the road—that is to say, to drive piles down at intervals at the lower side of the sleeper, otherwise the combined effort of the steep slope, the vibration, and the pressure of the pinions would cause the whole permanent way to shift gradually downwards, distorting itself at the curves. In the very steep tourist lines in Switzerland the seats in the cars are inclined so as to be as nearly level as possible when on the grade.

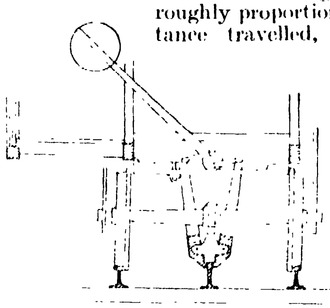


11. ELEVATION OF STRUB RACK

In the two railways last referred to, which are on very steep inclines to mountain summits, and in similar ones, there is evidently no alternative between the rack or rope and stationary engine, and any other system. Adhesion alone is out of the question. But it sometimes happens that in a section of an ordinary railway, where a mountain range has to be overcome, a choice may lie between a comparatively easy adhesion grade and a steep rack. In the former case it would be necessary to climb the mountain side gradually in order to attain a given elevation, the line being made much longer than it otherwise need be, or developed, as it is called, curving round spurs and valleys for the special purpose of giving the necessary length in proportion to the height, so as to have a workable adhesion grade.

In the latter case, the height, by means of the steep grade which the rack admits of, can be reached in a very much shorter length. Each problem of this kind has its own conditions, and must be solved on its own merits, no general rule being possible. However, the advantages and otherwise of each alternative may be briefly shown.

Respective Advantages. First, as to the adhesion line. This has the advantage of involving no departure from the usual type of permanent way and engine proper to the rest of the line, the latter running through the whole length; and though by the Abt combination engine this could be done, yet if the rack forms only a small portion of the whole railway the pinion mechanism would be largely unemployed. If the rack engines were limited to the short-rack incline, unless there were a very large traffic they would be probably often standing idle waiting for traffic. Secondly, as to the rack; the cost of construction, apart from the rack, would be less, not only because the line would be shorter, but because, being less limited as to grade, greater choice of alignment is open to the surveyor when locating it. Again, the construction and maintenance of the permanent way, though heavier mile for mile, might be much less, owing to the shorter length, and, apart from the pinion mechanism, the wear and tear of all rolling stock, which is roughly proportionate to the distance travelled, would be less. Thirdly, the dead weight of engine in proportion to load drawn is less, so that the fuel, etc., expended per ton of paying load lifted is less.



12. SECTION OF STRUB BRAKE

Subject to the last consideration, the actual mechanical work, and therefore the working cost of raising the load, would be much the same in each case, for the greater speed on the adhesion line would be neutralised by its greater length.

Where, in any general railway system, a rack section is interposed between two groups of ordinary lines, such, for instance, as a connection between a coast and a tableland country, the rack grade should not, if possible, exceed that on which an ordinary engine could draw itself up. Otherwise the circulation of engine stock between the two systems would be hampered.

Rack railways have had their chief development in Switzerland, Austro-Hungary, and Germany, but they are in use also in France, North and South America, Australasia, India, Japan, and other countries. The development has not been great in the United Kingdom, the necessity for steeply-graded railways being limited.

Railway Construction concluded

CHEMICALS IN FOOD

The Value and Danger of Certain Chemicals in Milk and other Foods. Tea as it Should be Made. The Alkaloids—Animal and Vegetable

By Dr. C. W. SALEEBY

Benzoic Acid. The acid which has the formula C_6H_5COOH is the characteristic constituent of the gum known as benzoin, and is found in various balsams. It used to be extracted from benzoin by sublimation. This process carries away with the acid a certain quantity of the volatile oil contained in the resin, thus giving it a very pleasant odour. Nowadays, however, the acid is largely prepared from coal-tar. It crystallises into very delicate and very light colourless needles. In the presence of water vapour it is volatile. It is only very slightly soluble in cold water (1 part in 400), but dissolves readily in hot water, alcohol, and solutions of alkalies. We have already seen that this acid is the valuable constituent of *Friar's balsam*. It is a powerful and volatile antiseptic. When administered internally, it is found that benzoic acid appears in the secretion of the kidney as a closely allied acid called *hippuric acid*. This acid may be regarded as a compound of benzoic acid and the body known as *glycocoll* or *amido-acetic acid*, which has the formula $C_2H_5NO_2$. This is a rather remarkable case of synthesis, the building up of compounds into more complex compounds within the animal body. Outside the body, hippuric acid can readily be converted into benzoic acid and glycocoll by boiling it with dilute hydrochloric acid.

Benzoic Aldehyde. Benzoic acid, C_6H_5COOH, corresponds to benzoic aldehyde, C_6H_5COH, just exactly as acetic acid, CH_3COOH, corresponds to acetic aldehyde, CH_3COH. Furthermore, we know that acetic aldehyde is derived by removal of two atoms of hydrogen from ethyl alcohol; similarly, benzoic aldehyde has corresponding to it an alcohol known as *benzyl alcohol*, which contains two atoms of hydrogen more than the aldehyde, having the formula $C_6H_5CH_2OH$. The aldehyde may be produced by oxidation of the alcohol, which thus loses two atoms of hydrogen. Its natural source, however, is of very great interest, and has already been referred to. The oil of bitter almonds contains a highly complex body which, since it yields glucose on decomposition, is known as a *glucoside*. It has the name of *amygdalin*, derived from *amygdala*, the botanical name for the almond. This amygdalin is normally decomposed by a ferment known as *emulsin*, which is also a normal constituent both of the bitter and the sweet almond. The action of the emulsin is to hydrolyse the amygdalin, and the products are sugar, benzoic aldehyde (which is therefore often known as *oil of bitter almonds*), and prussic acid. When the so-called oil or aldehyde has been purified by the distillation of the prussic acid, it is quite harmless, as well as pleasant. The reaction, which depends upon the presence of moisture, is represented by the following equation, the first term of which is the formula of amygdalin:

$$C_{20}H_{27}NO_{11} + 2H_2O = C_6H_5COH + 2C_6H_{12}O_6 + HCN$$

Benzoic aldehyde, often known as *benzaldehyde*, has reactions which closely correspond with those of acetic aldehyde; thus, nascent hydrogen reduces it to its alcohol, and oxidising agents form benzoic acid from it.

Salicylic Acid. Very closely allied to benzoic acid is *salicylic acid*, which is, indeed, a hydroxy-benzoic acid—that is to say, benzoic acid, one of the hydrogen atoms of which has been replaced by hydroxyl. Thus its formula is $C_6H_4 . OH . COOH$. This acid is known in commerce in two forms. One is known as the *vegetable acid*, being derived directly from the vegetable world, while the other is known as the *artificial acid*, or *synthetic acid*, but must ultimately also have its origin referred to the vegetable world, coal being a vegetable product. A comparison of the two processes of manufacture is of interest, and of very considerable practical importance. The plant known as the *winter green* yields an "oil of winter green," the chief constituent of which is a methyl salt of salicylic acid. This methyl salicylate readily yields salicylic acid on decomposition. This natural or vegetable acid is relatively very expensive, but has the great virtue of purity. Thus, the salicylate of sodium formed from it, and now recognised as one of the most valuable of all drugs, is pure and safe.

On the other hand, salicylic acid, destined to be a source of salicylate of sodium, may also be prepared by the action of carbon dioxide upon the carbolate of sodium. If dry carbon dioxide be passed through this salt at a temperature of about 400° F., an impure sodium salicylate results, and this, under the action of hydrochloric acid, yields salicylic acid. The following is the equation for this interesting reaction:

$$2C_6H_5ONa + CO_2 = C_6H_4 . ONa . COONa + C_6H_5OH.$$

Pure salicylic acid occurs as needle shaped, colourless crystals soluble only to the extent of 1 part in 500 of cold water, but readily soluble in hot water, alcohol, and ether. Watery solutions of it yield a beautiful reddish violet colour, with a solution of ferric chloride.

The artificial acid is extremely cheap, and is widely used as (1) a source of sodium salicylate for medical purposes and (2) a preservative of foods—for it is a very powerful antiseptic indeed.

Synthetic Salicylic Acid. The synthetic acid, however, invariably contains a considerable quantity of impurities—allied acids

called *cresotic acids*. Certain of these are very highly poisonous, so that extremely minute quantities of them may cause serious symptoms. Now, sodium salicylate is a drug which has to be administered in very large doses, so that the difference between two or three pence and 7s. 6d. per lb.—which represents the ratio of the two prices, at any rate—is an important matter. The use of the salicylate of sodium derived from the synthetic acid has led to the belief that the drug is dangerous, especially to the heart, and must be used with caution. The salt which is derived from the natural acid, however, and which contains no salts of cresotic acid, is remarkably free from any injurious consequence, and as much as 300 grains of it have been given in a dose without any injurious result. In the case of a drug which is the only known specific for a disease so important as rheumatic fever, these chemical considerations demand most serious attention. It is worth noting that just as benzoic acid unites with glycocoll in the kidney to form hippuric acid, so salicylic acid unites with glycocoll to form what is called *salicyluric acid*.

Salicin. Salicylic acid derives its name indirectly from the willow tree, the botanical name of which is *Salix*. The bark of various species of Salix contains a crystalline glucoside known as *salicin*, which, under the influence of a mildly alkaline fluid and warmth, is decomposed, yielding glucose and salicylic acid. This decomposition occurs in the blood, and the value of the acid was first discovered by the administration of salicin. The pharmacologists are at present unable to tell us why the salicylate of sodium is so extremely valuable in rheumatic fever, but the great student Professor Binz, of Bonn, has suggested that the salt is decomposed by the carbonic acid which is known to exist at a considerable pressure in inflamed joints, and that salicylic acid, a powerful antiseptic, is thereby liberated slowly and without irritation. Rheumatic fever is known to be due to a microbe, so that this most attractive explanation may possibly be verified some day.

Salol. Another close ally of salicylic acid deserves mention. Its common name is *salol*, and it may be regarded as phenyl salicylate, being prepared by the interaction of salicylic acid and carbolic acid, and consisting of sixty parts of the former and forty of the latter. This is an extremely insoluble substance, but is very valuable indeed as an antiseptic in the bowel, the reason being that it undergoes no decomposition until it is subjected to the action of trypsin—the powerful ferment which it meets in the bowel, and which slowly decomposes it, with deliberation of the two potent antiseptics of which it is composed.

Salicylic Acid in Food. It remains for us to discuss the extremely important question of the use of salicylic acid as a preservative of food, and thereafter we must raise a few general considerations concerning the chemistry of food preservation; this being a practical subject of very great importance, which is now recognised as a matter for discussion and examination by various chemical authorities. Salicylic acid may be chosen as a typical chemical preservative of food, since it is used in enormous quantities, and in foods of very diverse kinds. In certain foods, salicylic acid, we have lately learnt, is a natural constituent, as, for instance, in such fruits as strawberries, plums and oranges. Hence the acid will occur in many jams, and this must be remembered, since it is the favourite antiseptic employed for jams and other forms of preserved fruit, as well as for a number of wines which may also naturally contain it. Besides being artificially added in considerable quantities to jams, wines, syrups, cider, perry, and beer, salicylic acid has "also been found in butter, sauces and ketchups, in meat juices, potted meat and sausages, in sherry, port, ipecacuanha wine, and orange and quinine wine. Occasionally it is employed, either alone, or more usually in conjunction with boric acid, for preserving milk and cream." This and the following quotations are from the most complete study of the subject in English: "Preservatives in Food, and Food Examination," by John C. Thresh, M.D., D.Sc., F.I.C., and A. E. Porter, M.D., M.A. (J. and A. Churchill, 1906).

Specific Value as a Preservative. The report of the Departmental Committee appointed in 1889 by the President of the Local Government Board to consider this subject shows that salicylic acid is generally sold under various trade names, like other chemical preservatives. This acid is not employed in very large proportions in any article of diet, and according to the best authorities "the declaration of its presence and amount will probably meet most of the objections that can reasonably be raised to its use." Other authorities discussed the subject quite recently, and have, more or less, refuted the assertions that the acid as used is injurious to health. The excretion of the acid is extraordinarily rapid, and since it does not tend to accumulate in the body, it has no cumulative action. Salicylic acid seems to be almost invariably found in lime-juice preparations, and especially in lime-juice cordial. "There is, apparently, no evidence that salicylic acid, employed as a preservative, has ever produced any injurious effects." The acid is one of those used for the preservation of milk, though much less frequently than boracic acid. Its use for this purpose is definitely to be condemned. It is very commonly found in cream and butter. In both of these cases, the use of boracic acid, if any preservative is to be used, is much preferable.

Official Recommendations. In concluding this brief study of our subject, and as an introduction to the study of the chemical preservation of food in general, we quote in full the very important recommendations which conclude the report of the Departmental Committee referred to.

"(*a*) That the use of formaldehyde or formalin, or preparations thereof, in food or drinks be absolutely prohibited, and that salicylic acid be not used in a greater proportion than one grain per pint in liquid food, and one grain per

pound in solid food. Its presence in all cases to be declared.

"(*b*) That the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constitued an offence under the Sale of Food and Drugs Act.

"(*c*) That the only preservative that it shall be lawful to use in cream be boric acid, or mixtures of boric acid and borax, and in amount not exceeding 0·25 per cent. expressed as boric acid. The amount of such preservative to be notified by a label upon the vessel.

"(*d*) That the only preservative permitted to be used in butter and margarine be boric acid, or mixtures of boric acid and borax, to be used in proportions not exceeding 0·5 per cent., expressed as boric acid.

"(*e*) That in the case of all dietetic preparations intended for the use of invalids or infants, chemical preservatives of all kinds be prohibited.

"(*f*) That the use of copper salts, in the so-called greening of preserved fruits, be prohibited.

"(*g*) That means be provided, either by the establishment of a separate Court of Reference, or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and colouring matters in food, and to prepare schedules of such as may be considered inimical to the public health."

The use of salicylic acid and other preservatives in milk is forbidden in Austria-Hungary, Belgium, France and Switzerland.

Chemical Preservatives in Foods. To a race of city dwellers, the preservation of food is a vital matter, for it is a necessary condition of their life. Means to this end have been adopted from time immemorial. Whether chemically or otherwise, food most certainly must be preserved from decomposition if city populations are to be fed. Here we have no concern with what is in general, the safest, simplest, and best method of preserving food – that is to say, of killing the microbes which it contains. This method is boiling, or in any other way raising the food to such a temperature that the microbes in it are killed. In general, the methods include exposure to great heat, and to great cold —this latter being of the utmost importance in the preservation of milk—the exclusion of air, drying, smoking, and the addition of salt, boracic (boric) acid, formalin, salicylic acid, alcohol and many other substances. A number of these means are not only innocent and effective, but necessary. The addition of chemical preservatives, our present concern, cannot be excluded from the number of these. The recent official inquiry showed that "practically every person in the United Kingdom who has passed the suckling stage consumes daily more or less food containing chemical preservatives. It is obvious, therefore, that if such food were markedly deleterious, some conclusive evidence should have been forthcoming." On the other hand, the extensive use of these processes coincided with a steady fall in the death-rate, "and it is very probable that one of the causes of this decline is the better feeding of the people in consequence of the introduction of cheaper foods, this being rendered possible by the use of chemical and other means of preservation. . . . The dangers arising from the use of preservatives have been greatly exaggerated. It is impossible to say definitely that a single case of illness has ever been conclusively traced to the preservative used in any article of food or drink." On the other hand, "danger may be apprehended from the indiscriminate use of certain preservatives. It may be desirable that there should be some restriction as to their employment, and that in certain cases their use should be forbidden, as, for example, in milk."

A Proof of Success. The public, if it were capable of learning the lesson, has lately been provided with an astounding proof of the practical success which attends processes of food preservation—in this case chiefly by heat. The tinned products of Chicago, we now know, are prepared under conditions which, until the last moment, are abominable in the highest degree. The food is infected with every kind of dirt, filth, and disease, and much of it is mere refuse from the first. Consumed in such a state it would spread death everywhere, yet millions and millions of people live and thrive on it. As the present writer has said elsewhere, "if, then, the preservation of food is a science so far advanced that it can actually make a palatable, nutritious and safe product, such antecedents notwithstanding, it is surely evident, *à fortiori*, that when the antecedent conditions are decent we may place very great faith indeed in the methods already known." This is the contention which Drs. Thresh and Porter have conclusively proved in their most important treatise. They show that methods of food preservation, for instance, enable the poor to be supplied with good, wholesome food at low prices which would have to be multiplied manifold if these methods were unknown. It is well that society should protest against abominations such as those of Chicago, but it is well also that our actions should be qualified by knowledge, and that we should seek merely for the legitimate use of methods, many of which have been found necessary and successful for ages past. How long, for instance, is it since sodium chloride—that is, common salt—was first added to food in order to preserve it?

Why Milk Should not be Adulterated. And now, having endeavoured to state properly the general principles of this matter, let us consider and emphasise to the utmost a conspicuous and all-important exception. It concerns the most important of all foods, *milk*. It is the most important because it is the best of all foods, and because its state is a matter of life and death for every one of us during the first years of life. It is an ideal food, not only for man, but also for microbes. It is constantly used for this purpose by bacteriologists, who know no better "culture medium." Hence this best of foods is the most in need of preservation. When contaminated, as it constantly is, it may become the most deadly of poisons. The most common decomposition undergone by milk

consists in that lactic acid fermentation which we have already discussed. On the whole, this lactic acid fermentation may be regarded as practically innocent; Professor Metchnikoff, as we have seen, thinks that even more may be said for it. All the other decompositions and contaminations of milk may be regarded as more or less deadly.

The Slaughter of Children. The lamentable thing is that whereas the innocent fermentation has a result obvious to the nose and the palate, the deadly fermentations and contaminations are inconspicuous to those organs—though they play a great part in the death-rate, killing babies in tens of thousands every year and forming one of the chief factors, if not the chief factor, in the spread of tuberculosis—the most deadly of all diseases—of diphtheria, typhoid fever, scarlet fever, and many other diseases of less importance. Now, the second most unfortunate fact is this—that the lactic acid bacteria can be killed by proportions of chemical preservatives, such as boracic and salicylic acid and formaldehyde, which are not injurious to health and which do not affect the flavour of the milk. But these bacteria are the most delicate of all that infest milk, and the proportions of preservatives which kill them are impotent to affect the dangerous microbes, though these proportions unfortunately succeed in keeping the milk sweet and, therefore, apparently safe. No more unlucky combination of facts could be imagined. We say, then, dogmatically—and this is one of the most important facts for the public health that can possibly be stated—that the use of chemical preservatives in milk does not lessen in the slightest degree any dangerous properties that the milk may possess, but interferes merely with the multiplication of innocent microbes which, as we have seen, if allowed to multiply, would themselves arrest the development of certain dangerous microbes.

The conclusion, therefore, is that the use of chemical preservatives for milk is invariably useless. But this statement is only a feeble indication of the real facts, as we shall see in a moment. Here let us meet the objection that such methods are inevitable.

Preservatives in Milk Unnecessary. It has been conclusively proved, as, for instance, by the Aylesbury Dairy Company, which deserves all honour, that it is possible to supply, as they do, "at least a hundred thousand persons a day in London with milk absolutely free from preservatives, although a portion of their supply comes from Wiltshire, and even Cheshire, a distance of 200 miles." Ninety-eight per cent of the milk sold in Liverpool is free from any preservatives. Milk can be sent long distances and yet be supplied in a good condition to the consumers without the addition of any preservative and without the aid of heat. This can be done by immediate and efficient cooling, which ought to be a legal necessity in the case of all milk sold. Quoting again from the report of the Departmental Committee, we may note that the Aylesbury Dairy Company, who used to add 0·2 per cent. of boracic acid to their cream, have, for several years, been able to supply cream absolutely free from antiseptics. And the same is the case of the cream supply in Copenhagen. This last city is the model for the whole world in these matters. The only butter free from boracic acid which we import into this country comes from Denmark. We conclude, then, without any question or possibility of dispute that the use of preservatives in milk is unnecessary.

Dangerous to the Health of Children. We must go further, and say that their use is dangerous. This, as we have already seen, cannot be because of their mere presence in the milk. It depends upon the comparative chemistry of the lactic acid bacteria and the dangerous bacteria that commonly contaminate milk, in their relation to chemical antiseptics. The point, and the whole point, is that the addition of these preservatives to milk, killing the lactic acid bacteria but no others, *cloaks the results of the dirty conditions* under which the milk may then be produced. The report of the Departmental Committee contains a paragraph objecting to the use of preservatives in milk on the grounds that "there is evidence pointing to an injurious effect of boracised milk upon the health of very young children." The report goes on to say that there are no means of controlling the amount of preservative that may be added to milk. "The farmer or producer sometimes applies it; so does the wholesale purveyor; so does the retail dealer; lastly, the domestic use of preservatives is increasing, and has become very general, and hence the milk may receive a fourth dose before it reaches the unsuspecting consumer."

The Need for Cleanliness in Milk. But all these matters are relatively trivial. The vital objection is dealt with in the thirteenth paragraph of the report—which we quote in full. It embodies statements which should be part of universal knowledge:

"There is this further objection to the use of preservatives in the milk traffic—that they may be relied on to protect those engaged therein against the immediate results of neglect of scrupulous cleanliness. Under the influence of these preservatives milk may be exposed without sensible injury to conditions which otherwise would render it unsaleable. It may remain sweet to taste and smell, and yet have incorporated disease germs of various kinds, whereof the activity may be suspended for a time by the action of the preservatives, but may be resumed before the milk is digested.

"It has been put before us that it is not possible to supply large towns, especially London, with new milk without the aid of preservatives; but we have received abundant evidence to prove that this is no more than a matter of organisation and system. No doubt the prohibition of preservatives in milk offered for sale would tend to the disadvantage of small retailers who have no cold storage, but this is not a

consideration which should stand in the way of a much-needed reform.

"As to the feasibility of conducting the traffic in the largest towns without preservatives we have no doubt whatever. In Denmark the use of all preservatives in milk is strictly prohibited, and the prohibition is stringently enforced. . .

London's Milk Problem. "In face of these facts," the report continues, "we are of opinion that it is idle to pronounce it impossible to supply London with milk not artificially preserved. The business would be attended with some inconvenience at first, but we are impressed with the need for facing that inconvenience, and for rendering the vendors of milk containing preservatives subject to penalties under the Sale of Food and Drugs Act. Obviously, the conditions under which milk is sometimes kept in the homes of the poor are likely to hasten the processes of decomposition, but we do not think this a sufficient argument in favour of the sale of chemically preservatised milk."

To this we may add that the argument is the more worthless in that the chemical preservation of milk in any proper sense at all is impossible, as we have shown. What has been said about milk applies entirely to cream—notwithstanding the small degree of licence suggested to be permitted by the Committee. [Since we prepared this subject for the reader the Local Government Board have issued a circular condemning the addition of any chemicals to milk.]

The Need for Legislation. Space does not avail for any further consideration of this very large and very important subject. For fuller study of it we would refer the reader to Swithinbank and Newman's "Bacteriology of Milk," and to the work of Thresh and Porter. We have been able merely to outline the general principles and to enter into some small detail regarding the most important aspects of the subject. We have had to pass unconsidered the comparative utility of many chemical bodies which are used, questions of the proportions which are effective and safe in each case, the relatively unimportant question of colouring matters (which now include the coal-tar colours, used very extensively in confectionery, jellies, jams, sausages, temperance beverages, and wines), and also the important practical matters of the detection and estimation of boracic acid, salicylic acid, etc., in actual samples of food. It is a pity also to have had to ignore the legal aspect of the question. The Food and Drugs Act of 1875 is in urgent need of revision, and it would be well for us to have a municipal laboratory in our large cities comparable to the famous laboratory in Paris. The Act of 1875 has led to conviction in cases where margarine or butter has contained as little as 51 grains of boracic acid per pound. In a case at Bootle the amount was actually 120 grains per pound. Conviction has frequently followed the detection of formaldehyde in milk and the presence of large quantities of salicylic acid in various substances, such as jam, marmalade, ginger wine, etc.

The day has for ever passed when chemistry consisted merely of the knowledge gained by the alchemists as they tried to transmute the baser metals into gold—or of little more; it has now invaded the whole of human life, and thus, as we consider in turn the more important organic compounds, it is both necessary and desirable that we should indicate the existence of great practical departments of chemistry, the importance of which increases daily.

Gallic Acid. We saw that salicylic acid is a hydroxy-benzoic acid. Of these there are many, of which two more must be discussed. These are *tannic* and *gallic* acids. Both are trihydroxy acids, three hyhroxyl groups being included in their composition. The formula of gallic acid is $C_6H_2(OH)_3COOH$. This derives its name from the curious excrescences which are found on the bark and the leaves of the oak and are called *galls* or *gall nuts*. These galls are due to the irritation caused by the deposit and growth of the eggs which a humble creature deposits in the substance of the bark or the leaf. The chief constituents of these curious galls are the two closely related acids which we are now discussing. Gallic acid is found in tea and coffee and may be obtained from various other vegetable sources. It may be obtained from galls by powdering them and boiling them with dilute sulphuric acid. In their natural state galls contain not more than five per cent. of gallic acid, and even as much as 75 per cent. of tannic acid. But this process causes the hydrolysis of the tannic acid with the formation of gallic acid, which crystallises out in white, silky needles or thin needle-shaped prisms, containing one molecule of water of crystallisation. The acid is soluble only in about 100 parts of cold water, but readily dissolves in hot water, ether, alcohol and glycerine. The most important chemical fact about gallic acid is that it has no power of coagulating albumin. We shall shortly see the importance of this. If gallic acid be heated it undergoes decomposition, yielding carbon dioxide and the body which is known as *pyrogallol*, *pyrogallic acid* or *tri-hydroxy benzene* and has the formula $C_6H_3(OH)_3$. This is a powerful antiseptic.

Tannic Acid. Much more important than gallic acid is its relative *tannic acid*, oftener known, perhaps, as *tannin*. It may be described as anhydrous digallic acid. We have already seen that it may be hydrolysed to form gallic acid by means of boiling with dilute sulphuric acid. A most important fact is that tannic acid undergoes a similar hydrolysis within the bowel, even at the temperature of the body, and is absorbed into the blood not as tannic acid at all, but as gallic acid or, rather, as the *gallate of sodium*. Gallic acid and its salts have no power of coagulating albumin. Hence, the value of tannic acid as an astringent, which depends upon its power of coagulating albumin, is absolutely confined to the skin, the mouth and the upper part of the alimentary canal. It is absolutely useless to administer this drug as a "remote astringent" since it undergoes the transformation we have seen.

Preparation of Tannic Acid. Tannic acid may be prepared from gallic acid by boiling a watery solution of the latter with arsenic acid, but it is very readily obtained from galls, which are powdered, are kept warm and moist so as to undergo a kind of fermentation, and from which the tannic acid can be extracted by a mixture of water and ether. Whereas gallic acid has an acid taste, the taste of tannic acid is very strongly astringent. To this astringency there is some bitterness added, and persons who like their tea to have "a little body" or taste in it are really seeking for a high proportion of tannic acid. The astringency of this acid ought not really to be described as affecting the nerves of taste. In reality it is none other than the local action of the acid, dependent upon the fact that it precipitates albumin (including the albumin of the cells that line the mouth) in the form of an insoluble tannate. Tannic acid is readily soluble in water and in alcohol. It forms with salts of iron a bluish black precipitate which is none other than ink. For this reason it is a matter of importance to the druggist that he shall not mix up, in one prescription, salts of iron and vegetable infusions or tinctures containing tannin. There is no real objection to the ink that is formed except that it gives the mixture a very unpleasant appearance. Tannic acid also precipitates alkaloids in general. Hence tannic acid or strong tea may form valuable antidotes in cases of alkaloidal poisoning.

The Abuses of Tannic Acid. We must now discuss in turn the uses and the abuses of tannic acid. This substance has no properties desirable for the human body in health. On the contrary, its chemical properties cause it to interfere, in proportion to the amount of it that is taken, with the processes of digestion from first to last. Its evil action begins in the mouth, where, by precipitating albumin, it interferes with the flow of saliva, and does not end till it reaches the bowel, the activity of the upper part of which is interfered with. The most familiar form of tannic acid is thereafter converted into gallic acid, which, as we have seen, has no astringent properties. The amount of tannic acid in a typical black tea is about 16 per cent., and in a typical green tea about 27 per cent. On the average, there is very much more tannic acid in Indian and Ceylon teas than in China teas. This difference is a matter of great importance because it suffices to make the China tea far more desirable as a beverage.

Tannic Acid in Tea. On this important matter we cannot do better than quote from the most authoritative book in English, the well-known work of Dr. Hutchison on "Food and the Principles of Dietetics." He says: "The composition of the infusion is of much greater practical importance than that of the leaves from which it is made. . . . The *caffeine* (or *theine*, the valuable stimulant alkaloid contained in tea and coffee) is so soluble that it is practically all dissolved out of the leaf immediately infusion has begun. With tannic acid this is not the case. There is certainly less tannic acid after three minutes infusion than after five, and less after five than after ten; but beyond that one does not find much increase, for by that time practically the whole of the soluble matters have been extracted from the leaf." In general, the proportion of tannic acid is much more affected by the length of infusion than that of caffeine. Hutchison quotes a large number of experiments made by others, and repeated and extended by himself, which show that "the longer tea is infused, the higher is the proportion of tannic acid dissolved out, while the proportion of caffeine, on the other hand, is but little affected. From this the practical inference is that if one wishes to avoid having much tannin in tea one should infuse it for as short a time as possible." In order to emphasise the great superiority of China tea, we may quote one series of experiments in which it was shown that while three minutes' infusion, on the one hand, and 15 minutes' infusion on the other, yielded respectively 7·7 and 7·9 per cent. of the tannic acid in a China tea, the figures for an Indian tea were respectively 11·3 and 17·7 per cent.

How to Make Good Tea. Dealing further with this very important matter, Dr. Hutchison shows—and the whole of expert opinion agrees with him absolutely—that tea should really be infused, not boiled or stewed, as is so often the case; also, that the amount of leaf commonly used is excessive; further, that infusion should be limited to, at most, four minutes, not only because prolonged infusion extracts too much tannic acid, but also because it "dissipates the volatile oil, to which much of the fragrance of a good cup of tea is due." It is also pointed out that the addition of milk or cream is to be commended on hygienic grounds—not, as might be thought, because the albuminous matter of the milk is a valuable food, but because it precipitates some of the tannic acid of the tea before it is swallowed, and so prevents it from doing harm afterwards. The reader would certainly not consider excessive the brief amount of space we have devoted to the chemistry of tea if he realised the very grave injury to the digestion which strong tea works in thousands of cases. A large part of the injurious effects of tea, commonly attributed to its action on the "nerves," is not really due to its stimulant ingredient at all, but to the injury which improperly made tea inflicts upon the digestion in virtue of the simple fact that tannic acid precipitates albumin.

The Uses of Tannic Acid. Ignoring the local medical uses of tannic acid, which all depend upon the important property already emphasised, we may refer briefly to the uses of this substance in the process of *tanning*, by which animal hide is converted into leather. And here it is necessary to point out that, as a matter of fact, there is a very large number of different kinds of tannic acid. Indeed, it may almost be said that every vegetable source of tannic acid yields a product somewhat different from every other. Hence, compound names have been invented. Ordinary tannic acid is known as *gallo-tannic acid*, since it is prepared from gall nuts; the bark of the

oak yields a *querci-tannic* acid, which does not yield gallic acid when it is boiled with sulphuric acid. The tannic acid in coffee, again, has been sharply distinguished, as also *catechu-tannic* acid and *kino-tannic* acid, derived from the vegetable products called *catechu* and *kino.* These two last are very much less soluble in water than ordinary tannic acid, and hence are of special value in medicine.

In general, it may be said that the process of tanning consists in the formation in the hide of a dense and insoluble tannate of albumen. Thus, the meal known as a *meat tea*, which ruins so many digestions, is almost equivalent to filling one's stomach with leather.

Naphthalene. In preparing for the study of the extremely important bodies known as *alkaloids*, we must begin with a substance, the supposed relation of which to benzene itself is very simple; this is known as *naphthalene*, and has the empirical formula $C_{10}H_8$. Long ago, Berthelot showed that we may suppose this, and many other complex bodies derived from the distillation of coal at high temperatures, to be formed by a synthesis from much simpler bodies, as the consequence of the action of high temperature alone. Thus, the quite simple substance ethylene, which we have already studied, yields not only benzene, but also naphthalene when it is passed through a porcelain tube kept at a high temperature.

Naphthalene is an important constituent of what is left when carbolic acid has been removed from coal-tar. It crystallises in the form of large, thin, and beautiful colourless plates which are only very slightly soluble in cold alcohol but readily in hot alcohol. It melts at about 80° C., and boils at 217° C. Small quantities of it are present in coal gas, and it is also added sometimes to ordinary coal gas—which is impregnated with naphthalene vapour just before it escapes from the burner—in order to increase its luminosity. Naphthalene also plays a part in the coal-tar colour industry.

Constitution of Naphthalene. There is every reason to believe that the molecule of naphthalene consists of two benzene rings joined together so that they possess two carbon atoms in common—the said carbon atoms, unlike the others in the molecule, not having hydrogen atoms attached to them. If the reader will draw two benzene rings for himself, side by side, he will readily discover the slight modification necessary to convert them into the graphic formula of naphthalene. A large number of chemical facts go to support this theory of the constitution of the body. Its numerous derivatives show a very close correspondence to those of benzene itself. The colour value of many of them has already been alluded to.

Chinolin. Very similar to naphthalene in many respects is the substance known as *chinolin*, the importance of which we shall soon see. It occurs in coal-tar. Instead of consisting of two benzene rings having two atoms of carbon in common, like naphthalene, chinolin consists of a benzene ring and a pyridin ring having two carbon atoms in common. The empirical formula of pyridin is C_5H_5N. It is a volatile, offensive-smelling base; it is, like benzene, very stable, and is found in coal-tar.

The chinolin thus constituted is a colourless, oily substance and, like pyridin, has a characteristic smell. Its special interest for us lies in the fact that it is very closely copied in constitution by the great group of organic compounds which are found in a vast number of plants, and also in the animal body under various conditions, and are known as *alkaloids.* A very large amount of work has been done on the pure chemistry of this great group of bodies in recent years, and lately a considerable number of them have been constructed by synthetic chemistry. Before we consider their characters in general, and those of the more important members of the group in particular, let us look as closely as possible at their relations to the compounds which we have lately been discussing. The importance of this question is two-fold. There is no need for us to emphasise its importance in pure chemistry; but it is important because the alkaloids in general exercise extremely marked and definite and sharply contrasted actions upon various kinds of living tissue. Now, it is coming to be found—as we are now well prepared to believe—that there is the most precise relation between the constitution of an alkaloid and its behaviour in the body. In other words, it is pre-eminently the alkaloids which promise to enable us to unravel many of the mysteries of the chemistry of life itself, and even of the chemistry of consciousness. Already they supply us with hundreds of facts which prove the relation between chemical constitution and pharmacological action—that is to say, action upon the life and function of various kinds of living matter.

The Evolution of the Alkaloids. Let us, then, briefly retrace the imaginary evolution of an alkaloid from the benzene ring. If it occurred to the reader to attempt to construct for himself the graphic formula of *pyridin*—which we have purposely omitted to discuss until now, so that he might have a chance of teaching it to himself—he would be able to guess that it is none other than the formula of benzene, with an atom of nitrogen substituted for one of the CH groups. This, then, being noted, there will be no difficulty whatever in writing the formula of chinolin, the constitution of which we have already described. Now, it can be shown that if we double the formula of chinolin, and make a few changes in the formula thus produced—changes no graver than the substitution of hydroxyl for hydrogen and so on—we obtain the formula of one of the most remarkable and important of all the alkaloids—namely, *morphia* or *morphine*. This has the complicated empirical formula $C_{17}H_{19}NO_3$, and the graphic formula naturally looks very complicated indeed, yet its architecture can be traced up without any difficulty from benzene through pyridin and chinolin.

Nor is this a mere lucky chance. On the contrary, we find that the simplest manipulations of the molecule of morphine, thus obtained, will provide us with many other alkaloids. The

abstraction from it of one molecule of water, for instance, gives us the very characteristic alkaloid known as *apomorphine*, which has a unique action upon one particular spot of nervous tissue, and that alone—namely, the spot in the lower part of the brain, the activity of which reverses the normal movements of the stomach and causes vomiting. This dehydration of morphia can easily be effected in practice, apomorphine being prepared for medical purposes by heating morphine in sealed tubes in the presence of hydrochloric acid. Then again, if we replace a hydrogen atom in the molecule of morphia by the methyl radical, CH_3, we obtain the alkaloid *thebaine* which, like morphia, is contained in opium, and has an action on the body directly and specifically antagonistic to that of morphine itself. Thus the one molecule will depress almost to the point of death the motor nerve cells in the spinal cord, while the other molecule, identical in every respect of its architecture, except, so to speak, for the substitution of hydrogen by methyl at one odd corner, will violently stimulate those very same cells so as to cause extreme convulsions. Obviously, these facts have a meaning and an interpretation which must some day be discovered.

The Properties of the Alkaloids. We have already seen that a large number of the alkaloids, including some of the most important of the group, are to be regarded as modifications of chinolin, and we have observed how a minute change in the molecule may cause complete reversal of the chemical processes displayed by the alkaloid when it is imbibed by certain living cells. Now, before we consider the properties of the alkaloids in general, we must note a fact which will help us to understand those general properties—the fact that the alkaloids may be regarded as compound ammonias, that is to say, ammonias in which hydrogen atoms have been replaced by various radicals, usually extremely complicated. This view of the alkaloids is justified by purely chemical considerations, but it is also strongly supported by those more remotely chemical considerations which are involved in the action of the alkaloids upon the body.

We may define the alkaloids, then, as highly complex derivatives of ammonia or of benzene, formed in nature by the action of living matter alone. As the name implies, they strongly resemble alkalies and, most notably, the alkali called *ammonia*. Thus their solutions are definitely alkaline in reaction, and with acids they form definite salts. All alkalies contain carbon, hydrogen, and nitrogen. The great majority of them contain oxygen. A few containing no oxygen are liquid, but the remainder are solids, usually crystalline. The best instance of a liquid alkaloid containing no oxygen is nicotine, which we must afterwards discuss. The alkaloids are found to be electro-positive on electrolysis. They are only very slightly soluble in water, but readily soluble in ether, alcohol, and chloroform. The solutions are very bitter to the taste. In general, we may say that ether dissolves alkaloids, water dissolves their salts, and alcohol dissolves both the alkaloids and their salts. If an alkali be added to the solution of an alkaloidal salt in water, the alkaloid is precipitated. Alkaloidal salts are formed on the plan of the salts of ammonia, as, for instance, in the formation of ammonium chloride, which is NH_3HCl. Water is not produced. All alkaloids yield precipitates with tannic acid, with tetrachloride of platinum, and with perchloride of mercury. In this respect the alkaloids are distinguished from the large group of substances found in the vegetable world, and known, in our present state of ignorance, as *neutral principles*.

Names in Chemistry. Of recent years chemists have made a serious attempt to obtain uniformity in the spelling of the names of the alkaloids. The authorised spelling nowadays is to terminate the name of every alkaloid in *-ina* as the scientific form of the name common to all countries. This we render in English as *-ine*. Closely similar bodies which are not alkaloids but neutral principles or glucosides are always to be spelt without the "e." Thus the termination we have indicated is recommended to be a conclusive mark of the alkaloidal nature of the substance to which it is applied. Hence the proper way to spell phenacetin is without a final "e"; and the same applies to the neutral principles such as *aloin* and to the glucosides such as salicin.

Structure and Function. Before we pass on we must insist once again upon the great importance of the alkaloids, dependent upon the intimate relations between their structure and their function. Students of biology and natural history are familiar with these two terms, and with the correlation between structure, on the one hand, and function on the other—anatomy on the one hand, and physiology on the other. Now, not only do the alkaloids exhibit the same correlation, but they promise to provide us with a key to the far greater questions of vital chemistry. Already we have noticed the effect of substituting a methyl for a hydrogen atom in morphine. Let us now add the general observation that a large number of alkaloids which may act in various ways in their original state agree in having a specific paralysing action upon the extremities of motor nerves just at the very point where these motor nerves are distributed to the ultimate muscular fibres—*provided that* a methyl has been substituted for a hydrogen atom in the constitution of the alkaloidal molecule. Instances of this are furnished by strychnine, on the one hand, and methyl-strychnine on the other. Similar facts are recorded of brucine and methyl-brucine and of thebaine and methyl-thebaine. Here, also, since our desire is to correlate different parts of knowledge, we may briefly note how the facts of chemistry and the facts of pharmacology agree with the facts of botany. It is found that plants of a given natural order yield alkaloids which are, in some cases, identical. In other cases the alkaloids are very similar in chemical constitution and, therefore, very similar in pharmacological action, or they may be markedly contrasted in pharmacological action because of

chemical differences which, though slight, are crucial. Of such differences we have already seen illustrations. Opposing though allied alkaloids are often found in one and the same plant.

Animal Alkaloids. Before we consider the characters of the most important individual members of the alkaloid series, we must note the existence of a large number of alkaloids which are of quite different origin, and which may be described as animal alkaloids. They are the products of decomposition produced in dead animal matter by the action of microbes, and their poisonous character has caused great attention to be paid to them. The most important of these animal alkaloids used to be called, and are still called, *ptomaines*. Thus we frequently hear of "ptomaine poisoning," but this word has been variously used at various times, and it is really best abandoned altogether, as also is the companion term *leucomaine*, which used to be applied to alkaloids formed during life within animal tissues. It is far better to use merely the term *animal alkaloids*, which furnishes us with a convenient term in contrast to the *vegetable alkaloids*.

Food Poisoning. The animal alkaloids produced in food material in the course of decomposition effected by microbes are the active agents in cases of food poisoning—properly so-called. Not so long ago it was generally supposed that cases of illness following the eating of pork pie and so on were all due to what was called ptomaine poisoning, and it is still recognised that these animal alkaloids are capable of causing very serious symptoms. These alkaloids are most commonly discovered in tinned food, in cases in which the tins are "blown"—the ends being made to bulge by the formation of gas within the tin. Various animal alkaloids have been identified and have been proved to be capable of causing very severe symptoms, but it is quite time for the public to recognise that the term *ptomaine poisoning* is misapplied in nine cases out of ten. As a matter of fact, it is actually doubtful whether a sufficiency of ptomaines occurs in any food-product, however bad, to cause really deadly symptoms. In short, we may almost venture to say that ptomaine poisoning is a myth. In general, these animal alkaloids are very much less poisonous than the most familiar vegetable alkaloids, and some of them are practically inert.

Microbes in Food. The truth is that the presence of these animal alkaloids in food is important, not in itself, but as an index to something else—the presence of active and possibly dangerous *microbes* in the food. In all probability it will soon be generally believed by experts that all cases of ptomaine poisoning are, in reality, not cases of *intoxication* by a chemical poison already present in the food, but cases of *infection* by living microbes present in the food. It is true that microbes cause their serious effects by the production of poisons within the body, but only very rarely are these poisons alkaloids at all, and even if they were, the true facts of the matter—facts which must markedly influence our action in regard to it—are widely different from those which were supposed when ptomaine poisoning, so-called, was first described. The latest authorities on this subject say, "In practically all cases, when a substance is being examined for ptomaines, it is found that the liquid containing them is far more poisonous than the alkaloids isolated therefrom."

In short, so-called ptomaine poisoning is really either poisoning by the non-alkaloidal poisons or toxins already produced by microbes in the food in question, or else is none other from the first than an infection by living microbes.

The Education of Public Opinion. It is high time that public opinion on this subject should be educated up to the level of present expert opinion and not to the level of expert opinion of twenty-five years ago. It is especially to be hoped that no reader of the course on Chemistry in the SELF-EDUCATOR will forget that the animal alkaloids, very interesting and important though they be, are not really responsible for so-called ptomaine poisoning. We may here quote from Drs. Thresh and Porter an account of what typically happens in cases of so-called ptomaine poisoning:

"A cow or pig is attacked with diarrhœa, possibly due to the *Bacillus enteritidis*, or an allied species, and some of the bacilli enter the general blood stream. The animal is slaughtered and the flesh possesses the normal appearance. Probably at this stage no bacilli can be detected in the muscles, but a rapid multiplication takes place after death, when the circulation has ceased. The meat is cooked or made into pies, or pickled; the process is insufficient to destroy the bacilli in the interior, and an epidemic results, or it may be that while the bacilli have been killed the toxins produced have escaped destruction, and these may be present in sufficient quantities to produce poisonous effects."

In short, the result of modern inquiry by chemistry, on the one hand, and bacteriology on the other, is to transfer the subject of ptomaine poisoning from the domain of the older science to that of the newer. Thus, the sooner the term *ptomaine* and the term *ptomaine poisoning* are abandoned, the better. The first is useless, and the second is entirely misleading.

Continued

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CANE SUGAR MANUFACTURE

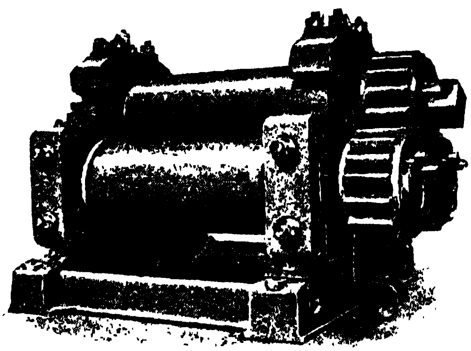
Separation of the Juice. Clarification. Concentration. Evaporation. Crystallisation. Sugar. Demerara Sugar. Curing. A Factory Described

WE will now outline the process of manufacturing sugar from sugar cane. The sugar cane is passed through a sugar mill, and the juice that is expressed is submitted to processes of purification. The juice is concentrated until the sugar is obtained in a crystalline form. The sugar is then prepared for the market, or "cured," and the molasses treated so as to recover from it any remaining sugar. These processes are conveniently considered in the following divisions:

1. Separation of the juice.
2. Clarification of the juice.
3. Concentrating and crystallising.
4. Curing the sugar.

Separation of the Juice. The canes are cut as described in the previous lesson, and within as short a time as possible passed through a mill which squeezes out the juice. The oldest form of cane mill was provided with wooden or stone rollers, but, except in some parts of India, these have been replaced by iron mills. The three-roller mill is the most used. In this, one roller, the "head" roller, is placed above the other two, and moves in the opposite direction to them. The mill is so arranged that the cane can easily enter, the pressure being increased by the adjustment of the rollers. In Stewart's cane mill additional power is obtained by means of a massive crushing head forced down by hydraulic pressure. Merrilees, Watson & Co., dispense with the use of hydraulic appliances and make a mill with yielding ends, by means of *toggle* levers acted on by springs.

The mill automatically relieves the pressure on one or more rollers and prevents jamming in case of irregular feeding. Simpler forms of mill have but two rollers [2], and others are used having rollers up to eight in number. The mills are often fed mechanically. As the crushing mill does not press out the whole of the juice, double and triple crushing are employed, and sometimes the crushed cane is soaked with hot water in its passage from one mill to the other. It is not possible to extract the whole of the sugar, but the loss is reduced to about one per cent. Recent patents embody the use of a diffusion process—a soaking in hot water in closed vessels—between the two crushings. The *bagasse* (crushed cane) from the first mill is passed into diffusers containing heated water, and after a time the bagasse is drained from the saccharine liquid, and pressed in the second mill. The weak liquid from the diffusers is re-heated and used in the diffusers for fresh bagasse. The diffusion process is universally used in making sugar from beet, and will be fully described in a later lesson. In manipulating sugar cane, diffusion is held to be a failure, as the results obtained by double and triple crushing are quite as favourable and much less expensive.



2. SUGAR CANE MILL
(A. & W. Smith & Co., Ltd., Glasgow)

Preparing the Cane. Various methods have been suggested for preparing the sugar cane for the mill, such as shredding and cutting up the cane. The Ross apparatus cuts the cane into four-inch lengths, then slices the pieces, and passes them on to the mill. The Fletcher machine, for a similar purpose, was patented in 1894, and can be regulated to secure a product of the desired degree of fineness. Several patents taken out by Kidd in 1893 were devised on the plan of submitting the comminated cane to the action of steam before passing it on to the mills, the idea being to facilitate the extraction of juice. The objection to the use of heat in cane juice extraction is that gummy matter, which causes much trouble afterwards, is removed. The limit of economical extraction of residual sugar from bagasse is soon reached when large quantities of water have to be evaporated.

The cane juice is next strained through a wire-gauze screen to remove pieces of cane and other mechanical impurities.

Clarification. The strained juice is then submitted to the *clarification*, or *defecation*, process. The juice is run into a large copper vessel heated by steam and raised to a temperature of 130° F. Milk of lime, in the average proportion of 4 oz. of quicklime to a gallon of juice, is then added, and the heat continued until a temperature of 180° F. is reached. At this temperature a thick scum rises, and when the scum shows signs of "cracking" the steam is turned off. The juice is allowed to rest, and the intermediate layer of clear juice drawn off into an evaporating apparatus. The scum

and sediment are transferred to a separate tank. The lime is used to neutralise the natural acids of the juice, which, if allowed to remain for any length of time, would cause inversion of the sugar.

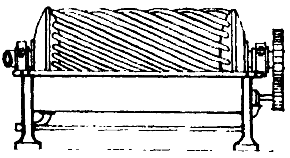
The heat removes the albuminous matters by causing coagulation, and the lime assists mechanically and chemically in removing the coagulated albumin as scum or sediment. The process of adding lime is called *tempering*, and as the quantity to be added varies, the lime is added until a faint alkaline reaction is indicated by means of litmus paper.

Continuous Defecation. Of late years continuous methods of defecation have been devised. Harvey's apparatus is a trough-like vessel heated by steam. Adjustable baffle plates or transverse divisions are fitted at spaced distances within the defecating vessel, forming practically separate chambers, while a settling chamber is fitted at the end of the defecator. Channels are arranged to draw away the scum and clear juice. By adjusting the temperature a continuous movement is given to the liquid, which readily parts with suspended matter in the settling chamber. In Deeming's superheat clarification method, the juice is heated in successive stages to a high temperature, and is thence passed to a special form of settling tank. This tank is a large cylinder with a conical bottom, and inside this is a conical vessel that reaches down to the conical part of the cylinder. The hot juice is conducted into the outer tank, and causes currents of juice which induce the sediment to fall into the conical bottom of the cylinder, the clear liquid being drawn off at the top.

The scums which have been yielded by the defecation process have steam blown into them to still further coagulate the albuminous matter and are then filtered, lime being sometimes added to assist the process.

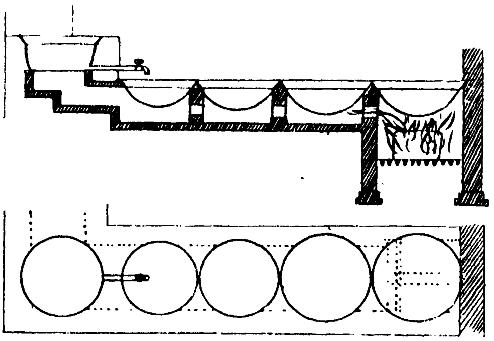
Carbonatation. An alternative process of clarifying cane juice is known as *carbonatation*. The method is always used in beet sugar manufacture, and is described at a later stage. The advantage claimed for the process in the case of cane sugar is that the resulting produce is purer and fetches a higher price than sugar submitted to the usual defecation process.

Concentrating. The next step in the manufacture of sugar is to remove the water from the clarified juice so that the sugar may be obtained in a solid state. Usually, this is done by evaporating the liquid until it reaches the syrup stage, when it is transferred to a vacuum pan, and concentrated until only 5 or 6 per cent. of water is left in the mass. The oldest method of evaporating the water from the sugar is effected by using a series of pans known as the *copper wall* [4]. A description of it is useful as leading to a consideration of the improvements which have been made on the primitive apparatus. The copper wall consists of a series of open pans called *teaches* or *taches*, the set of four being placed over a flue. The fire is at one end and is directly beneath one of the teaches, the heat passing along the flue to the chimney at the other end. The clarified juice is first placed in the pan nearest the chimney, and when it has been concentrated a little it is clarified out into the next one, and so on, until it reaches the pan over the fire, where the evaporation is continued until the crystallising point is reached, when the mass is ladled out into cooling vessels. In this method a good deal of fuel is wasted, and there is danger of overheating the sugar, which not only spoils the colour of the product, but results in *inverting* some of the sugar—that is, preventing crystallisation of the full quantity of sugar.



3. THE WETZEL EVAPORATOR

Introduction of Steam Pipes. The next step was to replace the open fire by steam-pipes in the pans. This led, owing to the choking of the pipes, to what are called *film evaporators*. The earlier patterns consisted of a cylinder heated by steam, revolving in a trough of sugar juice. This gave place to the Wetzel evaporator [3], in which the cylinder was replaced by a number of copper pipes. The steam passes through the pipes from one end to the other, the apparatus revolving in a trough of juice. A modification of the Wetzel plan is that in which *discs* are employed instead of steam-pipes.



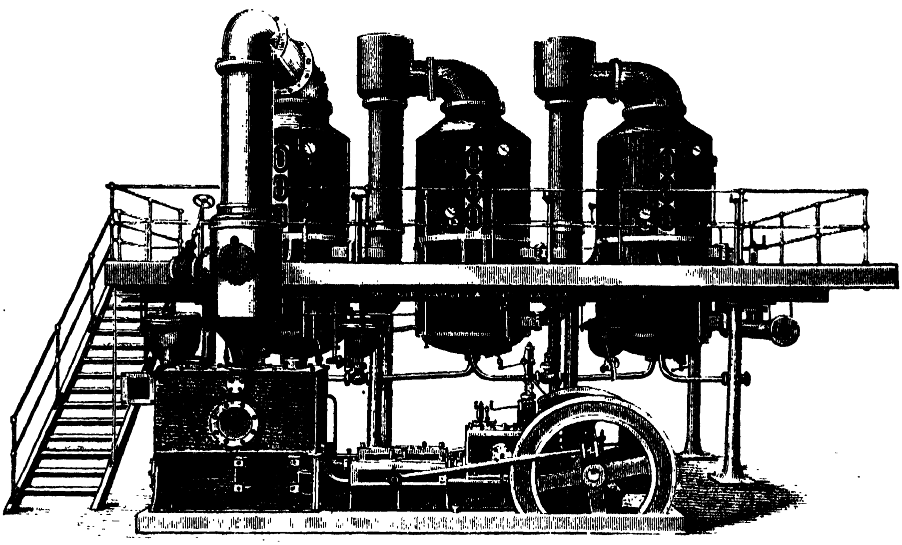
4. THE COPPER WALL

The Concretor. Fryer's concretor is a more economical method of applying heat to the evaporation of water. The object in the concretor is to pass a shallow stream of juice over a series of trays heated by an open fire or steam. The trays are divided by ribs running from one side nearly to the other, so that the liquid requires to take a narrow winding course during its passage from one end of the apparatus to the other. One of the concretors consists of a series of ten trays, measuring about 48 ft., and with the serpentine course which the juice must needs take, five or six times this length is traversed, and this in about five minutes. On leaving the last tray the juice is run into a trough with a revolving cylinder heated in its interior by hot air. The heating in this part of the apparatus is continued until the mass becomes flaky

instead of liquid, when it is discharged into casks, where it solidifies, and is ready for the refiner. The whole process takes about half an hour, and the average yield of concrete is about 2 lb. to the gallon of juice.

Evaporation Under Reduced Pressure. Howard, in 1813, patented a method of evaporating sugar by what are known as *vacuum pans,* which it will be convenient to refer to here. He found that by reducing the atmospheric pressure by pumping out the air from a covered pan solutions of sugar boil at a much lower temperature, and thus no risks were run of injuring the sugar by overheating. Further, the process was more rapid, as, owing to the lowering of the boiling point of the liquid, the difference in temperature between the heating steam and the boiling liquid is greater, and hence greater transmission of heat is obtained for a given heating surface. The heating of Howard's vacuum pan was effected by means of a steam jacket, but this was afterwards replaced by steam coils within the pan. The steam jacket is not an economical method of transmitting heat, as the air introduced with the steam forms a non-conducting medium in the upper part of the jacket. The remedy in this case was to blow off the steam every now and then by means of a tap. Roth introduced the use of steam-pipes, and Degrand endeavoured to utilise the vapours of the pan for heating a further quantity of liquid.

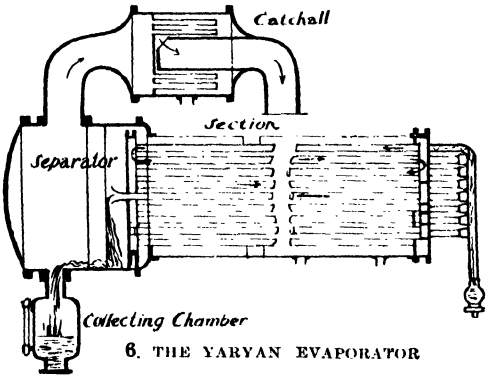
Multiple Evaporation. This plan of Degrand's was further developed by Rillieux, who designed a series of three vacuum pans, which he called *triple effet* [5]. The vessels are connected by means of valves so that the juice can be drawn successively from one to the other, but the most important principle is that involved in using the latent heat of steam three times over. Dr. J. Lewkowitch recently gave the following explanation of the principle of the multiple effet before a meeting of the Society of Chemical Industry: "Suppose," he said, "we have at our disposal heating steam of what is termed in practice *half an atmosphere* (or one and a half atmospheres expressed in absolute pressure), such as the exhaust steam from an engine. The temperature of such steam would be about 112° C. Suppose, further, that we have employed the best practical means for producing vacuum at the outlet of the third vessel, so that the temperature would be about 46° C. We have, therefore, a temperature difference of 112° – 46° = 66° C. available for evaporating purposes. This difference would have to be distributed over the three vacuum vessels or effets. If we make the heating surface of each vessel the same, it follows that the amount of water evaporated will be the same in each vessel. Consequently, the difference of temperatures in the three vessels must be the same—66/3 = 22° C. We have now the following state of affairs: the steam entering the first effet has a temperature of 112° C. We require 22° C. for raising the liquor in the first vessel to the boiling point; the liquor would then have a temperature of 112° – 22° C. = 90° C., and the vapours escaping from the outlet the same temperature of 90° C. To this temperature of the vapour corresponds the absolute pressure of 525 mm., or in technical parlance, a vacuum of 235 mm. —say 9 in. A gauge (*manometer*) fixed to the outlet of the first vessel would therefore register this vacuum. The steam enters the heating system of the second effet with a temperature of 90° C. The liquid in the second vessel requires 22° for raising it to the boiling point and has therefore the temperature of 68° C. If no loss of heat take place the temperature must be slightly higher, as the flow of liquid goes in the direction from the first effet to the second effet, and the liquid coming from the first vessel has



5. TRIPLE EFFET APPARATUS (McOnie, Harvey & Co., Ltd., Glasgow)

the temperature of 90° C.; but this point may be neglected here. The vapour escaping from this second vessel will have the temperature of 68° C., which corresponds to an absolute pressure of 213 mm. (8·5 in.) or a vacuum of 547 mm.—say, 21·5 in. This vapour of 68° C. enters the heating chest of the third vessel and brings the liquid therein to the temperature of 46° C."

The Yaryan Evaporator. Rillieux, the inventor of the system of multiple evaporation, employed horizontal cylinders furnished with a number of horizontal tubes. A disadvantage is that the steam passes through all the heating tubes with a uniform velocity, very low in the case of the second and third effets, thus making a rapid exchange of heat impossible. This led to the use of vertical vessels with shorter horizontal heating tubes such as are now employed. The next innovation was Yaryan's, in which the liquid is passed through narrow tubes while the steam circulates around them. Yaryan adopts in his apparatus [6] the two principles of evaporation *in vacuo* and multiple effet. The evaporator consists of a series of straight tubes passing from end to end of a shell or drum and coupled together by an ingenious arrangement of pockets to form coils, the main advantage gained being the ease with which the straight tubes can be examined and cleaned.



6. THE YARYAN EVAPORATOR

As a rule the coils consist of an odd number of tubes, the inlet being at one end of the evaporator and the outlet at the other. At the outlet end of the evaporator is a separating chamber in which the liquid discharged from the tubes is completely separated from the vapour. Below the separating chamber is a collecting chamber into which the liquid flows, whence it is drawn by superior vacuum into the vaporising coils of the second effet, in which it undergoes a second process of evaporation by means of the vapour that comes through the vapour pipe at the top of the separating chamber of the first effet into the shell of the second effet.

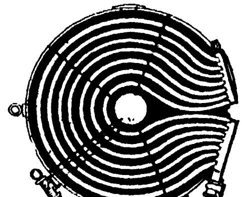
As noted above, evaporation takes place within the interior of the vaporising coils, the heating agent being outside the tubes, and as the rate of the feed of liquid to be evaporated is arranged so that it cannot fill these coils, there is never any depth of liquid to be displaced by the vapour in its endeavour to escape from the heating surface. In addition to this the rapid circulation induced by the formation of the vapour in the interior of the tubes promotes a movement which brings into play the whole of the heating surface in a manner not attained in the multiple effet.

Lille's Evaporating Apparatus. This apparatus, introduced in 1893, has for its object the separation of suspended liquid particles from the vapours evolved during the evaporation of liquids. By means of perforated plates the juice is distributed over a series of horizontal pipes arranged in a closed chamber. Steam is circulated through the pipes. The vapour from the juice passes through and around baffle plates into a prolongation of the evaporating chamber called the subsiding chamber. The baffle plates cause the suspended particles to separate and fall to the bottom of the subsiding chamber, whence they are drawn off by means of a pipe below. The vapour passes off by an outlet pipe in a dry state, the pipe being in the upper part of the subsiding chamber.

Harvey's Evaporators. Patented in 1899, these evaporators are constructed of a series of steam-pipes with vertical juice-circulating tubes and vapour generating vessels which are superposed in vertical columns so as to act as triple or multiple effet. Rapid circulation of the juice is attained and a quick rate of evaporation.

There are numerous other varieties of evaporators, but each will be found to fall within one of the general kinds enumerated above.

Crystallising. In the copper wall, Wetzel apparatus, and Fryer's concretor, the juice is converted into solid sugar, while in the multiple effet and Yaryan evaporator the juice is only reduced to a syrupy consistence—until it has lost 70 per cent. of its bulk. When the juice has reached this stage it is transferred to a *vacuum pan* and boiled until grains of sugar are formed. The vacuum pan [8] is fitted with two or three coils [7] of steam-pipe sufficiently separated to allow of free circulation of the contents of the pan. The pan is fitted with pumps for making a vacuum and a contrivance called a *proof stick* for obtaining samples of liquid from the interior without breaking the vacuum. The working of the vacuum pan is as follows: The air pump is started, and as soon as the vacuum reaches 26 in. or 27 in. the feed cock on the side of the pan is opened and sufficient liquor drawn in to cover the bottom coil. Steam is then turned into the coil and the liquor rapidly evaporates. Further supplies of liquid are admitted at short intervals, the feed cock being opened for about 15 seconds at a time until the contents of the pan show signs of "graining," when samples are taken with the proof stick. The grain is "fed" carefully, the cock being opened frequently and each time the quantity admitted


7. LYRE-SHAPED TUBES IN VACUUM PAN

increased. As the amount of syrup in the pan increases steam is turned on in the other coils until at the completion of the charge the pan is nearly full or up to the "bull's eye," or sight hole, in the side of the pan. In this way the grain "grows" in size. The whole skill of the pan-boiler consists in inducing the grains to grow to their utmost, and this can only be done very slowly and by manipulating the temperature.

Striking the Pan. The mass in the pan at the finish of the boiling is termed *massecuite*, and the operation of discharging or emptying the pan is known as *striking*. The striking point is judged by the firmness of a sample taken from the pan and suddenly cooled in water. When the grain is very small the pan is sometimes only half emptied and fresh syrup admitted, the half-emptying process being known as *doubling*, and the discharged massecuite as *first cut*. The process with pure juices can be repeated several times, but a point is reached at last when the crystals do not increase in size, and the whole charge is *struck*.

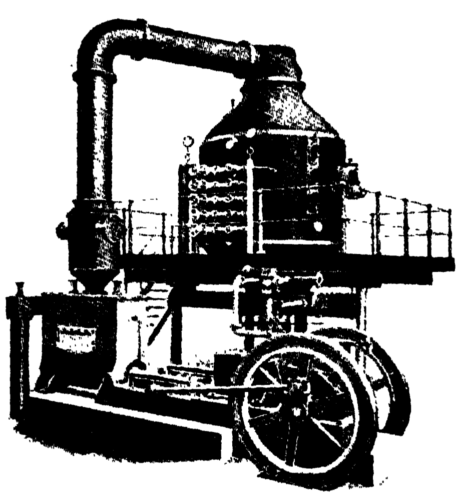
To save time in boiling it is now general to add sugar grains to the pan instead of forming grain from the syrup, this being known as *seeding*. In a pan containing about 30 tons of massecuite one ton of sugar is required, the sugar used being that recovered from the molasses.

Demerara Sugar. The yellow crystals known under this name are produced by adding to the massecuite sulphuric acid so as to slightly char the sugar grains, and give the bright yellow colour so much admired. About three gallons of sulphuric acid diluted with one and a half gallons of water is used for five tons of sugar. It was formerly the practice to employ a small quantity of chloride of tin, but this has been discontinued in view of the fact that the cumulative effects of the metallic impurity might be injurious, although no cases of bad effects have been reported. Artificially dyed sugar in which aniline colour is employed has been sold as Demerara sugar, but legal proceedings have now stopped this.

Curing the Sugar. The massecuite from the last operation consists of a mixture of crystalline sugar and molasses. The problem now is to separate the two. The oldest method is to run the massecuite into coolers and when set to dig out the mass and put it into casks with perforated bottoms. In this way the molasses drained out partially and yielded raw or *muscovado sugar*. This crude method has been replaced in most countries by treatment of the massecuite in centrifugals. This process and crystallisation in motion, which now accompanies it, is dealt with in the lesson dealing with refining.

The recovery of sugar from molasses is dealt with at the end of the article on beet sugar as the processes are common to the manufacture of cane and beet sugar.

Cane Syrup. There is such a decided preference in the United States for sugar in the form of syrup that attention should be concentrated on syrups. The Florida sugar cane is particularly well adapted for syrup production. In canning syrup the important point is to destroy all ferments in the syrup and the vessel by heat, and therefore prevent germs from entering. For family use fruit jars with rubber bands are quite suitable. Golden-coloured table syrup manufactured in Barbados and Porto Rico commands such a fancy price in the United States that it would pay the growers better to convert the whole of the cane sugar crop into syrup. The addition of a little citric acid helps to clarify the syrup and is advantageous, because it inverts some of the sugar and thus prevents crystallisation. When an acid syrup is used in cooking it advantageously reacts with the bicarbonate of soda employed as a baking-powder. The casks in which the syrup is stored should have been steamed and sulphured before being filled with syrup.



8. THE VACUUM PAN
(McOnie, Harvey & Co., Ltd., Glasgow)

Cane Sugar Factory. A factory capable of dealing with 100 tons of cane per 24 hours and employing engines of 150 h.-p., turning out 8 tons of sugar daily, could be erected and equipped for about £40,000. The cane mills are placed on the ground floor and the juice is pumped up to the top floor and descends as it is manufactured. In the laboratory a *polariscope*, such as is figured in the lesson on sugar testing, costs £40; a balance costing about £10 will also be required as well as dishes and other pieces of apparatus. The establishment of central factories has been urged as a means of resuscitating the sugar industry in the West Indies. A factory in which modern machinery and scientific control are installed would be able to obtain a better yield of sugar than smaller factories. The position of the factory would be determined by the facilities of transport, and if the factory were worked on a co-operative system among the cane growers friction would be avoided. In buying sugar cane the sugar yield is the only satisfactory basis.

Continued

Continued from page 3651

AN AGE OF MARTYRDOM

Fall of Cardinal Wolsey. Sir Thomas More. Accession of Edward VI. Queen Mary and the Persecution of the Protestants

By JUSTIN McCARTHY

WE must go back some years to record the fall and death of Cardinal Wolsey. His fall was as rapid as his rise. He displeased the King by his indecision about Henry's divorce, and his many enemies quickly took advantage of his misfortunes. In 1529 he was prosecuted under the Statute of Praemunire, and resigned his office of Chancellor. He was afterwards impeached in the House of Lords, but the Bill was thrown out in the Commons, partly by the influence of Thomas Cromwell and partly, it is said, by that of the King. His property was confiscated. He withdrew to York, but in 1530 was arrested on a charge of high treason. On account of his health he was allowed to travel to London by easy journeys, but he became so ill in consequence of an attack of dysentery that he had to stop at a monastery near Leicester, where he died on November 29th, 1530.

Sir Thomas More. The reign of Henry VIII. is made painfully memorable by the manner in which death sentences were inflicted on some of his most distinguished subjects. Sir Thomas More, scholar, author, and statesman, born in London, February 7th, 1478, came to hold high public offices. He was a member of the legal profession as well as of the House of Commons, was elected Speaker of the House of Commons in 1523, and was later made Lord Chancellor. Like Colet and Erasmus, with both of whom he was acquainted, More was of the new order of thinkers, and went with them in the desire for certain reforms in the Church. But he could not consent, any more than they, to a complete rejection of the ecclesiastical authority of Rome. When Henry VIII. was declared head of the English Church, More, who had resigned the office of Lord Chancellor in 1532 because he was altogether opposed to the King's assumption of supremacy, refused to recognise any other head of the Christian Church than the Pope. His refusal to take the Oath of Supremacy was made the occasion for a charge of high treason against him, and after more than twelve months' imprisonment he was sentenced to death, and was beheaded on July 7th, 1535.

The Career of Thomas Cromwell. The fate of Thomas Cromwell is another event of Henry's reign which has been almost universally condemned, although not, as in the case of Sir Thomas More, through admiration for the character of the sufferer. Thomas Cromwell is said to have been the son of a blacksmith and innkeeper in Putney, and to have served in his early years as a common soldier in Italy, and then to have been a clerk in Venice, Antwerp, and other places. He returned to England and became very successful as a lawyer and money-lender; he attracted the attention of Cardinal Wolsey, who made much use of his services, and was probably the means of getting him into the House of Commons. He became Wolsey's secretary, and through him got into favour with King Henry. Cromwell advised the King to declare himself the supreme head of the Church of England, so that he would thus be able to settle the question of his divorce in his own Ecclesiastical Courts. Cromwell's action also brought about the suppression of the monasteries, although it is understood that he himself remained a member of the Church of Rome. He was made Chancellor, Secretary of State, and, finally, Earl of Essex. Then the tide of success suddenly turned, the reaction against Henry's claims to absolute spiritual domination set in, and Henry found himself embarrassed by the unpopularity of Cromwell's measures and character.

When Henry could no longer with safety make use of any favourite minister, it seldom cost him much time to discover the quickest way of getting rid of the encumbrance. Cromwell had not been for quite two months the bearer of an earl's title when he was arrested on June 10th, 1540, and sent to the Tower. He was accused of high treason by the Duke of Norfolk, was not allowed any form of trial, but was condemned on a Bill of Attainder, an antiquated and odious practice which had been much favoured by Cromwell himself during his days of power.

The Bill of Attainder. The effect of a Bill of Attainder in those days was that when once it had been declared in force by the ruling powers against any obnoxious person that person was thereby put outside the range of legal trial, and had to be forthwith condemned. Cromwell was accordingly beheaded on Tower Hill, July 28th, 1540.

There were several other executions during the reign of Henry VIII. which seemed as sudden and as capricious in their character as those we have mentioned, executions which appear to have been mere judicial murders, committed to gratify some humour or to secure some supposed interest of the sovereign. The foreign policy of Henry continued for some time in alternations of antagonism, now with France and now with Germany, but the historical responsibility for this continuous warfare cannot be laid altogether on the shoulders of the English monarch. The whole condition of Europe at that time tended to resolve itself into a struggle for superiority between England, Germany, and France, the great rising and rival Powers of the world; the political life of Europe was then only at an early stage of development, and there seemed to

be something going on which resembled a mere struggle of organic physical forces.

Peace Between England and France. France gave much excuse for some of Henry's hostility to her by her constant endeavours to obtain control over Scotland, and to convert the northern and the southern division of the British island into two entirely separate States, the Scottish kingdom becoming a sort of partner with the realm of the French monarch. In 1546 a peace was concluded between England and France which, among other advantages to Henry, relieved him for the time from the interference of the French monarchy with Scotland. Henry's life was now drawing to a close. He had overtasked himself in every sense, had put a strain upon all his powers, physical and intellectual, had had too much work, too much pleasure, too much passion, and his life came to an end on January 28th, 1547, when, according to our modern estimate of man's age, he had not long passed the most vigorous period of his existence.

History is still engaged in controversy concerning the political and personal character of Henry VIII. He lived and reigned during a period when one of the greatest political and religious convulsions which had come upon Europe since the birth of Christianity was passing over England. By one class of historians he is regarded as one of the greatest impelling forces of that movement, while by others he is set down as merely one of its involuntary instruments. Many of his deeds as a sovereign and a man are incapable not merely of defence, but even of excuse; and the most favourable plea that can be made for these passages in his career is that other monarchs have committed sins as great and have yet been allowed by the general verdict of posterity to have made their country greater and stronger than they found it. So much, at least, must be acknowledged when we study the reign of Henry VIII. He made his country greater than he found it, and if his life was stained with sin and crime, it must be owned that he lived at an age when the successful maintenance of his country against many powerful enemies was believed to be a sovereign's best excuse for his sins against the codes of morals and religion.

Edward VI. The reign of Edward VI. is memorable chiefly because of some of the strange and even grotesque incidents and characters which it encloses. Edward, the son of Henry VIII. by his third wife, Jane Seymour, was only in his tenth year when he succeeded in the January of 1547. The boy's uncle, Edward Seymour, Earl of Hertford, in defiance of the will of Henry VIII., by which Edward VI. succeeded to the throne under the regency of a council of sixteen members, mostly Reformers, got himself made Protector to the young sovereign. He invaded Scotland in 1549, with the object of enforcing the contract of marriage between Edward and the Scottish princess, afterwards famous in history as Mary Queen of Scots. Mary was the daughter of James V. of Scotland, and was born at Linlithgow on December 8th, 1542, when her father was lying on the bed of sickness from which he was never to rise. Mary thus became a queen a few days after her coming into the world. It was arranged by the Regent of Scotland that Mary should be given in marriage to Prince Edward of England. The Scottish Parliament, however, annulled the contract; thereupon the English Protector invaded Scotland, and the Scots were defeated at Pinkie on September 10th. The marriage between Edward of England and Mary of Scotland was not accomplished, and Mary was affianced to the Dauphin of France. The Protector, who had now created himself Duke of Somerset, received information, on his return to England, that his brother, Lord Seymour, an Admiral in the Service, had been intriguing against him, which Somerset regarded as intriguing against the welfare of the King and the State; and without troubling himself about considerations of family and feeling, he had Lord Seymour executed in March, 1549. Lord Seymour was the second husband of Catherine Parr, widow of Henry VIII.

The End of The Protector. In the same year there were two uprisings in England, one of the Catholics in Devonshire, who felt themselves heavily oppressed by the new laws following the Reformation, and another of the discontented agrarian population around Norwich. Both risings were suppressed without much mercy by Somerset. But Somerset's power was soon to come to an end. He found an opponent in the person of John Dudley, Earl of Warwick, who was making himself very influential throughout England. The country turned against the Protector; he was accused of ambitious designs dangerous to the State, and was executed on January 22nd, 1552. No sooner was Somerset executed than the country found it had reason to regret him, for the new manager of affairs proved to be even a more selfish and, if possible, a less statesmanlike ruler. Dudley's great ambition was to bring his own family into the line of succession. He had by this time obtained the title of Duke of Northumberland, and married his fourth son, Lord Guildford Dudley, to Lady Jane Grey, who was the granddaughter of Mary, younger sister of Henry VIII., and to whom, by the will of that sovereign, the crown was to pass if there were no children of Edward or of either of his sisters, Mary and Elizabeth.

The young King was now dying of consumption, and Northumberland induced him to consent to a project for the exclusion of his sisters from the succession, and the nomination of Lady Jane Grey. He prevailed on Edward to accept this arrangement, and a declaration embodying its purpose was formally drawn up. The boy King died at Greenwich on July 6th, 1553. Northumberland was supposed by some to have hastened his death by poison, but of this there is no authentic evidence. Edward had no opportunity of proving that he had any capacity for rule, though he seems to have possessed much of the talent as well as some of the vices of the Tudors, and he lives in history only as a name.

On the death of Edward, Mary, daughter of Henry VIII. by his first wife, Katharine of Arragon, became Queen. Mary was born at Greenwich on February 18th, 1516. She had been remarkably well educated, loved reading and books, could read many languages, and was devoted to the Church of Rome. Northumberland had prevailed upon his half-brother and his Council to set aside her claims. Lady Jane Grey was actually proclaimed Queen in London, July 10th, 1553, but had no support. The force of public opinion throughout the country was exerted for the maintenance of Mary's claim, and she received a triumphal welcome on her public entrance into London. The English people had become thoroughly weary of Northumberland and his policy, and he and two of his confederates were sentenced to death and executed.

A Friend of Rome. It was not long before Queen Mary began to take measures to prepare the way for the restoration of the old form of faith in England. She restored to their Sees the Catholic Bishops who had been dispossessed, and she even went so far as to imprison some of the most prominent Reformers, although she did not as yet venture to take any steps for the re-establishment of Papal supremacy. Her first great trouble arose out of her proposed marriage with Philip of Spain, only son of the Emperor Charles, who afterwards became, on the death of his father, the sovereign of Spain, the two Sicilies, the Netherlands, Mexico, Peru, and other regions. Philip became the husband of Mary, in spite of the protests raised against the marriage by the great majority of the English people, who regarded Spain as the enemy of England, and were convinced that the union of their Queen with the Spanish prince could mean nothing less than an attempt at the restoration of the Catholic religion.

One of the first measures taken by the new Queen and her Council was the bringing of Lady Jane Grey to trial, her imprisonment in the Tower, and her sentence to death. Lady Jane Grey might probably have been spared if she had consented to give up the Protestant faith, but she scorned every proposal made to her, and the rebellion raised by Sir Thomas Wyatt against the marriage with a Spanish prince only served to stimulate the supporters of Mary to the harshest deeds. Mary at this time suspected her sister Elizabeth of complicity in Wyatt's rebellion, and imprisoned her in the Tower. As no evidence could be found against her, however, she was released in a few months and sent to Woodstock in the care of Sir Henry Beddingfield. Lady Jane Grey, her husband and father were publicly executed in 1554, even before the marriage of the Queen.

Protestant Persecution.. After the marriage began the reign of persecution, which brought upon the Queen the odious and well-remembered popular name of "Bloody Mary." How far Mary was responsible for the cruelties committed in her name it is hard to say, for she appears to have had at the opening of her public career a generous and a loving nature; but she certainly made herself responsible for the outrageous acts of persecution committed during her reign. Cardinal Pole, an Englishman by birth, was sent over to England as a Papal delegate, and became one of Mary's most favoured counsellors, and was created Archbishop of Canterbury. Such eminent men as Latimer, Ridley, and Cranmer were tried for heresy, found guilty, and burnt at the stake. Latimer was burnt with Ridley in front of Balliol College on October 16th, 1555.

It is believed that during the last three years of Queen Mary's reign no less than 300 victims of religious persecution were put to death on the scaffold or at the stake. We must bear in mind that in those days religious persecution by ruling powers expressed itself in deeds unknown to the modern world, and that long after the reign of Mary there was a persecution of Catholics which brought its victims to the axe and to the flames. But even for Mary's time such cruelties were extravagant, and have marked the history of her reign with a horror which must live for ever among the world's most ghastly records. Mary, meanwhile, suffered from many disappointments. She was the victim of long illness; she had found that her husband was selfish and worthless, and it was a bitter disappointment to her that she had no children to maintain the succession.

Calais Recaptured by France. She dragged the country into a war against France to support her husband, who had succeeded to the dominions of Spain. The people of England could not throw their souls into this war, and it had hardly begun when the French won a decided victory and recaptured Calais, which had been taken by Edward III. Mary was wounded to the heart by this calamity, for which she must have felt herself to be mainly responsible. Her health broke down completely, and she died on November 17th, 1558.

Before the war had gone much farther, England was left without any territory in France. If Mary had lived longer, it is probable that the country would have risen against her disastrous rule. Her death at that crisis seemed to light a ray of hope in the hearts of the majority of her subjects, whose patience was almost exhausted.

Continued

METALLURGY

Classes of Ores and the Various Methods of Recovering their Metal Contents. The Physical Properties of Metals

By A. H. HIORNS

METALLURGY originally implied a knowledge of the art of extracting metals from their ores in a sufficient degree of purity to enable them to be employed for industrial purposes. The methods employed were largely empirical, depending partly on chance and partly on knowledge handed down often from father to son; and although great skill was acquired by the workman, only special ores could be treated, with the expenditure of enormous labour and an excessive consumption of fuel. At the present time metallurgy is tending to become a true science. The importance of the professional art is diminishing each year before the applications of science, methodically conducted by experts in every branch of the subject, who are applying the laws of chemistry, physics, and mechanics to metallurgical operations of all kinds.

What is Metallurgy? The term *metallurgy* has now acquired a much more extended meaning; it includes a knowledge of the properties of the various metals and the modes of their application to manufacturing purposes. It comprises a number of physical and mechanical operations many of which are conducted at very high temperatures, so that a knowledge of the principles of heat and refractory materials is necessary. Metallurgy is essentially a chemical art, and an acquaintance with that important branch of science is necessary to its study. But metallurgical *chemistry* is a special branch of chemical science which does not come within the ordinary sphere of academic teaching of chemistry, and purely analytical and laboratory methods are often inapplicable to processes conducted on the large scale at high temperatures.

Only a few years ago temperatures were determined in a very uncertain manner, the temperature of a metal being judged by the changes of colour perceived by the eye, and the terms dark red, cherry red, orange, white, yellow, etc., were used to express different temperatures. Now a manager without leaving his office or laboratory may ascertain each moment the precise degree of temperature of a furnace or of a metal by placing in it a thermo-couple, which generates a current of electricity, the value of which is signified by a suitable recorder.

Ores. Metals occur in nature in ores, which may be termed *metalliferous matter.* Ores require special preparation before they are submitted to the smelting operation. The ore proper is associated with more or less extraneous matter, termed the *matrix* or *gangue.*

The nature of an ore depends on the nature and condition of the contained metal. Iron ores are seldom smelted when they contain less than 30 per cent. of iron. Ores of lead and zinc are poor with 30 per cent., while a copper ore is considered very rich with 30 per cent. of the metal. Silver, and especially gold, ores are very valuable when they contain a few ounces to the ton. The metallic minerals are generally oxides, carbonates, silicates, sulphides, arsenides, chlorides, etc., sometimes alone, but very frequently associated together, forming *complexes.* The gangue may consist of quartz, lime and magnesia, silicates, flourides, sulphates, etc., and these sometimes perform useful functions in the extraction of the metal.

Classes of Ore. Ores may be classified under two chief categories—ores with earthy gangue and ores with metalliferous gangue; the latter are chiefly oxides and carbonates of iron and iron pyrites. Many metals occur in the earth as sulphides, and these are often converted into oxides and carbonates by the action of air and moisture, so that many sulphides are found with a cap of oxide or carbonate.

Ores vary considerably in the amount of metal they contain and in the nature of the contained metals. In many cases there is only one metal present; in others the ores are complex—that is, they contain two or more metallic compounds, hence it is often necessary to submit them to preliminary processes, such as washing, crushing, dressing, and roasting, in order to prepare them for smelting.

Concentrating Ores. It is desirable to crush most ores to a more or less finely divided state. For rough crushing a rock-breaker is generally used, and for fine crushing a stamp battery or a pair of rolls. After crushing valuable minerals, it is often necessary to submit the material to a concentrating process, whereby the lighter gangue is mechanically separated from the heavier and more valuable metalliferous matter. Concentration is best effected by the agency of water, the mineral matter being separated by its higher specific gravity. When a mixture of light and heavy particles of equal size is stirred up with water and allowed to settle, the latter naturally sink towards the bottom, and the former settle towards the top. If such a mixture be conveyed by a stream of water, and the course of the stream be slightly checked, the heaviest particles will subside first. By passing the stream through a series of receptacles the grains may be collected according to their specific gravity. By allowing a stream of water to flow over very finely-divided ore, spread out on a slightly sloping surface, which is slowly revolving, the lighter particles are swept away, leaving the heavier behind.

Roasting or Calcining. Ores, after having been suitably prepared by mechanical means, may be treated directly for the extraction of the

metal or submitted to a preliminary operation termed *calcining*, or *roasting*, at a moderate temperature, in order to expel volatile matter, and, if necessary, to convert the metal into the form of oxide which is chiefly effected by the oxygen of the air. In some instances it is desirable to form a sulphide, an arsenide, or a chloride, in which cases sulphur, arsenic, or chlorine takes the place of oxygen; such an artificial sulphide is termed a *regulus*, and the arsenide a *speise*.

In the case of sulphides the roasting may be conducted so as to remove the whole of the sulphur, when it is said to be "dead-roasted," or it may be necessary to remove only a portion of the sulphur. In some instances the roasting is performed at a moderate temperature so as to convert one or more of the sulphides into soluble sulphates. If the temperature be allowed to rise too high, the sulphates are decomposed, forming oxides. With some sulphide ores the roasting has to be very carefully conducted to prevent partial fusion and clotting. To prevent this, lime or some other inert substance is added to the charge. Clotting is very marked in ores containing sulphide of lead or antimony.

Metallurgical Processes. Metallurgical processes may be classified under the following heads:

1. LIQUATION. In this process an easily-fusible metal or compound may be separated from an infusible or difficultly-fusible one by taking advantage of the different melting points. In this way bismuth and sulphide of antimony are obtained from their ores, and argentiferous lead is separated from copper.

2. DISTILLATION AND SUBLIMATION. By heating ores of mercury and arsenic the solid metals are driven off in the form of vapour and condensed in a liquid or solid state.

3. REDUCTION OF OXIDES AT HIGH TEMPERATURES. Reduction of oxides is usually effected by heating with carbon or carbon compound, or other bodies having a greater affinity for oxygen than is possessed by the metal.

4. REDUCTION OF SULPHIDES BY IRON. Lead and antimony are reduced by iron at high temperatures, forming sulphide of iron and liberating the metal.

5. LEAD METHOD OF EXTRACTION. Gold and silver are extracted from certain of their ores in virtue of their solubility in molten lead.

6. ZINC METHOD OF EXTRACTION. Gold and silver are separated from lead by means of molten zinc.

7. MERCURY OR AMALGAMATION METHOD OF EXTRACTION. Mercury is used cold for extracting gold and silver from their ores, the mercury being afterwards driven off by heat.

8. WET METHODS OF EXTRACTION. By means of acids and saline liquids, ores of copper, silver, nickel, etc., are dissolved, and the metal or a compound of the metal is precipitated by another metal or reagent.

9. ELECTROLYTIC METHODS OF EXTRACTING AND REFINING. This method is employed for the production of aluminium, nickel, and several of the rarer metals, such as calcium, chromium, molybdenum, etc.; also for the refining of copper, silver, and nickel. Iron is also now being extracted by electric furnace methods.

10. By the action of highly oxidisable substances on metallic salts, as in the precipitation of gold from its solution by ferrous sulphate.

11. CRYSTALLISATION. Lead is crystallised out from a molten bath of argentiferous lead in what is known as Pattinson's Process, and argentiferous zinc is removed from lead on a similar principle in Parkes' process.

Metals are extracted from their ores by dry or furnace processes, by wet processes, and by electro-chemical processes.

Physical Properties of Metals. Metals are capable of existing in the gaseous, liquid, solid, and semi-solid states, and although the properties vary according to the physical state, the difference is one of degree rather than of kind. A *solid* is a body which can, to some extent, resist a change of state, or which can, to a certain degree, sustain a vertical pressure without being supported laterally. Metals may be regarded as typical solids. A *liquid* consists of particles which have considerable mobility, and may therefore be moved about among each other with the greatest facility. Hence two different metals mixed together in the liquid state will diffuse into each other and form an alloy.

A liquid differs from a solid in being destitute of the power of sustaining pressure unless supported laterally, and its surface will be flat when the whole mass is at rest. A semi-solid, or plastic body, possesses properties intermediate between those of a solid and those of a liquid. Wrought iron at a welding temperature is a good illustration of the case in point. A gas is distinguished by the power of indefinite expansion, so that, however small the quantity, it will at once expand and fill the empty vessel, however large, in which it is placed, and will exert a pressure against the interior surface in all directions.

Liquid and Solid Metals. Liquids and gases are all included under the general name of *fluids*. There are many points of resemblance between solids and fluids which it will be useful to consider now. All substances are porous, because the particles of which they are composed are not absolutely in contact at every point, but are more or less separated by intervals of empty space in the interior.

All such cavities which can be perceived, even with the aid of the most powerful microscope, may be termed *sensible pores*, but the different molecules, of which the mass of any matter is composed, are also separated by spaces which no optical instrument can enable one to detect, and it is probably in virtue of such spaces that gases can be absorbed by metals and possibly condensed to a liquid state.

In a similar way may be explained the fact that mercury will penetrate, and even pass through, many metals. Thus, a bar of tin is easily permeated by mercury without being

destroyed, although the mercury makes it very brittle. In consequence of porosity both liquids and solids are sensibly compressible, but the latter more so than the former.

"Flow" of Solid Metals. Solids may be made to flow like liquids under the influence of pressure, otherwise it would be impossible to fashion metals into various shapes by the mechanical processes of hammering, rolling, and spinning. One of the best illustrations is that of lead, which is made into pipes and other shapes by *squirting*, as it is called, in an apparatus constructed on the same principle as the syringe. The forging of iron may be cited as another good example of the flow of a solid. Even a brittle solid is not destitute of this property, if time be allowed to enable it to flow from one point to another. Professor Spring has also proved that the particles of a metallic powder may be forced into a compact mass by strong compression. In this way alloys have been perfectly formed without the aid of heat, and possessing much the same properties as they would when formed in the usual way by fusion in a crucible. It has been shown that the ease with which fluids diffuse into each other is characteristic of the fluid state. But Professor Abel has proved that carbon in a plate of solid steel can pass from it into a plate of solid iron if the two plates be tightly pressed together, even at the ordinary temperature.

Lastly, liquids, when exposed to the atmosphere, or especially when placed *in vacuo*, gradually vaporise, and solid mercury when solidified by extreme cold slowly evaporates.

Colour and Lustre. Most of the white light which falls upon a polished surface is reflected, but a small portion is absorbed, and this, being decomposed, is robbed of certain of its constituents, and the residual rays produce the effect of colour. In some metals, such as copper and gold, the absorption is more marked, hence copper is red and gold is yellow, while most of the other metals are white or greyish white. The differences of colour enable one to distinguish one metal from another. The colour of a metal is often modified by the presence of an impurity, and in some cases the nature of the impurity may be judged by the difference in the shade of colour. The lustre of a metal is independent of its colour, and depends upon the perfection of its power of reflecting light.

It varies with the purity and the degree of polish which has been imparted to it. The same metal may have a different colour according to the state of division of its particles. While most metals are opaque, some are semi-transparent, and transmit only certain of the constituents of white light. Thus gold leaf is green when observed by transmitted light.

Fusibility. All metals are fusible, but some require the very highest temperature to melt them. When strongly heated, metals pass from a brownish red to a clear red colour, which gradually increases in luminosity and transparency to a dazzling white. It is convenient

PHYSICAL PROPERTIES OF METALS

Metal.	Melting point in degrees Centigrade.	Specific gravity	Electric conductivity. Mercury 1.	Tenacity in tons per square inch approximately
Aluminium	625	2·56	31·7	12
Antimony	632	6·71	2·0	0·5
Arsenic ..	500	5·67	2·7	0·5
Bismuth ..	268	9·8	0·8	0·5
Copper ..	1,080	8·82	55·9	8·5
Gold ..	1,060	19·32	43·8	7
Iron ..	1,600	7·86	8·3	25
Lead ..	326	11·37	4·8	1
Mercury ..	39	13·59	1·0	---
Nickel ..	1,500	8·8	7·4	25
Platinum ..	1,770	21·5	8·3	22
Silver ..	960	10·53	57·3	10
Tin ..	232	7·3	8·2	6
Zinc .	420	7·15	16·9	7

to use three colours to express roughly certain ranges of temperature, thus:

Incipient red	525°	Centigrade.
Dark red	700°	,,
Cherry red	800°	,,
Orange	1,000°	,,
White	1,200°	,,
Dazzling white ..	1,500°	,,

The following table gives the approximate melting points of various metals:

Metal	Melts at	Metal	Melts at
Tin	232° C.	Silver ..	960° C.
Bismuth	268° C.	Gold ..	1,060° C.
Cadmium	320° C.	Copper ..	1,080° C.
Lead ..	326° C.	Nickel ..	1,500° C.
Zinc ..	420° C.	Palladium	1,500° C.
Antimony	632° C.	Pure Iron	1,600° C.
Aluminium	625° C.	Platinum	1,770° C.
Magnesium	750° C.	Iridium ..	2,500° C.

Advantage is taken of the fusibility of a metal to produce castings from a given pattern and to join metal parts together by soldering. Metals with high fusing points, such as iron, are used for fire-bars, melting-pots, and similar purposes [see also article beginning on page 2862].

Crystallisation of Metals. On solidification after melting, metals usually crystallise. Crystallisation also occurs when metals are condensed from a state of vapour, or deposited from solutions by means of electricity. This crystallisation of metals is of great importance, as the formation of crystals in metals due to continued vibration, intense cold, sudden alterations of temperature, or the presence of impurities may render a metal absolutely useless. Crystallisation may serve to indicate the quality of a metal, as in the case of foundry pig iron; to indicate the presence of impurities, as in the case of antimony in lead; or to separate metals on the large scale, as in the Pattinson process of desilverising lead.

Density or Specific Gravity. The density of a metal depends on the closeness of contact between the molecules. It is influenced by the crystalline structure, temperature of casting, rate of cooling, mechanical treatment,

and the purity of the metal. The density of a metal is increased by wire-drawing, hammering, rolling, or other compressive force, which closes the pores. With the exception of bismuth, all metals are denser in the solid than in the liquid state. The densities of the metals are as follows:

Platinum	21·5	Copper	8·82
Gold	19·32	Cadmium	8·60
Mercury	13·59	Iron	7·86
Palladium	11·20	Tin	7·29
Lead	11·37	Zinc	7·15
Silver	10·53	Antimony	6·71
Bismuth	9·80	Aluminium	2·56
Nickel	8·80	Magnesium	1·74

The specific gravity of gold, being very high, renders it very suitable for coinage. On the other hand, the much lower relative weight of iron is an advantage in building, and aluminium, owing to its strength and lightness, is useful for many purposes where lightness is desirable.

Toughness. This is the property of resisting fracture by bending, twisting, or similar means, after the limit of elasticity has been passed. This is well exhibited in the case of copper and lead.

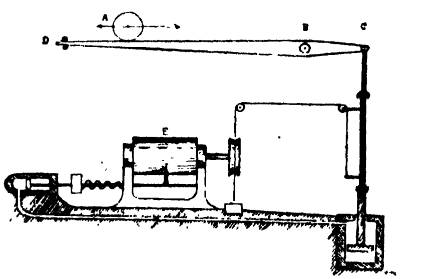
Malleability. When a body can be permanently flattened under a hammer or between rolls without cracking, it is said to be *malleable*. If it break, it is termed *brittle*. Malleability depends on tenacity and softness. During the working of metals, the particles are forced into unnatural positions, but by heating the mass strongly, and allowing it to cool slowly, they are brought back to their normal state. This is termed *annealing*. Gold is the most malleable of metals, combining the two properties of softness and tenacity in the highest degree. Some metals are malleable when hot, but not when cold; they are then termed *cold-short*. Other metals are just the reverse, and are then termed *hot-short*. Ordinary zinc is malleable only at 100° to 150° C. The order of metals for malleability is as follows: gold, silver, copper, tin, platinum, lead, zinc, iron, and nickel.

Ductility. When a metal can be drawn into wire, or lengthened by a tensile force combined with lateral pressure, without breaking, it is said to be *ductile*. The ease with which it can be reduced will depend on its softness, but the thinness to which it may be drawn will depend on its tenacity, which property has more influence on the ductility of metals than on their malleability. The rate at which the traction is applied also exerts considerable influence on the ductility. The following metals are arranged in the order of their ductility: gold, silver, platinum, iron, nickel, copper, zinc, tin, and lead.

Tenacity. This is the property of metals by which they resist, in varying degrees, the separation of their molecules by the action of a tensile stress. It not only varies with each metal, but also with the physical condition of the metal. It is generally diminished by a rise in temperature, while the reverse is often the case with regard to malleability and ductility. Some metals have a low tenacity, and are then often brittle. The tenacity or tensile strength is determined on a straight bar, held firmly at one end, and a gradually increasing weight applied at the other end until it breaks. The strength is usually expressed as the number of tons or pounds required to produce the rupture of a one-inch-square bar.

Elasticity. This is the property in virtue of which a body returns to its original bulk after its shape has been altered by external pressure. Any body which is thus capable of recovering its shape is said to be a *perfectly elastic body*. When a bar of metal is submitted to a tensile stress, it increases in length proportional to the weight applied. When a certain limit is reached, the stretching or strain increases more rapidly than the load, and then the bar will be permanently stretched. The point at which the stress and strain ceases to be proportional is termed the *limit of elasticity* of the metal. The elastic limit, breaking stress, and elongation, are of prime importance. In designing structures it is more important to know how much weight a metal will sustain without permanent distortion than to know its breaking stress, in order that the greatest load may be applied well within the elastic limit of the material.

Testing Metal Strengths. The above characteristics are determined by means of a tensile testing machine. This machine is made with two pairs of jaws in which the test piece is held, one pair being generally connected with the ram of a hydraulic cylinder and the other end with a lever carrying a weight, by which the tensile stress exerted by the ram is measured. Some machines have the jaw and test pieces so arranged that a pull is produced in a vertical plane, while in others the jaws are arranged so as to work horizontally. Sometimes it is advisable to obtain the stress within the limit of elasticity. This is determined by an arrangement similar to the following. A single lever



1. HYDRAULIC APPARATUS FOR TESTING METAL STRENGTH

carries a poise which measures the load, while the pressure is applied by means of a hydraulic ram [1]. The ratio of BC to BD is 50 to 1. The poise is one ton, and when it is at D, it balances 50 tons at C. E is a revolving drum which is actuated by the wire attached by clips to the specimen which is being elongated. The pencil, which is actuated by pressure in the hydraulic press, has an axial motion proportional

to the stress; a stress-strain diagram is thus obtained. Some materials, such as cast iron, are tested for their transverse strengths. The standard test piece for cast iron is 3 ft. 6 in. long, 2 in. deep, and 1 in. wide, thus allowing for a distance of 3 ft. between the supports. [See also article beginning on page 1391.]

Welding. When two pieces of metal are joined together by pressure to form one compact piece, they are said to be welded. It is necessary that the metals should be soft, with clean surfaces, and that they should possess considerable malleability and toughness. The requisite conditions for welding iron are obtained only at a high temperature with the metal in a plastic state. The motion of the molecules at a high temperature is raised to such a degree that they are capable of penetrating into each other. Steel requires to be welded at a much lower temperature than iron because of its lower melting point, and because the carbon is liable to burn off if the heat be too intense. Soft metals like lead can be welded at the ordinary temperature.

Forging. When a metal is capable of being hammered out into various shapes, the operation is termed *forging*. This property is the same as malleability, but has a more limited meaning. Forging is an illustration of the solid flow of metals. [See also article beginning on page 2983.]

Soldering. This term is applied to the operation of joining two surfaces of a metal or metals together by heat. In what is termed "lead burning," as used by plumbers, two pieces of lead are fused together at the edges by means of the oxy-hydrogen blowpipe, as in some cases the introduction of solder would not be admissible. This is the case with the sheet-lead lining of acid chambers. Solders are divided into two classes—*hard*, or fusing with difficulty, and *soft*, or easily fusible. When a red heat is required to melt the solder the operation is termed *brazing*. Brass solder belongs to this class. The solder must in all cases have a lower melting point than the metal to be soldered.

Hardness. Hardness or resistance to abrasion or cutting is generally increased by the presence of impurities in a metal, so that softness in many cases is a test of purity. The softness increases with an increase of temperature. Manganese, nickel, and cobalt are the hardest, and lead one of the softest of metals. Hardness depends on the degree of attraction of the molecules for each other.

Brittleness. When a metal readily breaks into fragments by the occurrence of a sudden shock, or if a metal be unable to resist fracture when subjected to a compressive force, as in rolling, it is termed *brittle*. Brittleness is not hardness, as sealing wax, for example, is brittle but not hard. A substance is brittle when it does not elongate under pressure. If a metal be crystalline and the cohesion between the crystals be feeble, then the metal is brittle.

Sonorousness. This property is possessed by the harder metals, and is very marked in certain alloys, such as those of copper and tin. Impurities often increase the sonorousness of a metal, as in the case of antimony in lead.

Conductivity. This is the property different metals possess of transmitting heat and electricity. The conducting power of metals for heat is as follows:

Silver ..	1,000	Tin ..	152
Copper ..	736	Iron ..	119
Gold	552	Lead ..	85
Magnesium ..	343	Platinum ..	84
Aluminium ..	313	Antimony ..	40
Zinc	281	Bismuth ..	18
Cadmium ..	201	Mercury ..	13

In electrical language the resistance of a metal to the flow of an electric current is more often used than the conductivity, the latter property varying inversely as the resistance. The resistance of metals is increased by a rise of temperature and diminished by a fall of temperature. The following table gives the conductivity for electricity of the metals in a pure state:

Silver ..	1,000	Iron ..	164
Copper ..	999	Tin	152
Gold	806	Lead ..	88
Aluminium ..	551	Nickel ..	79
Zinc	302	Antimony	42
Platinum ..	167	Mercury ..	25
Palladium ..	164	Bismuth ..	12

Structure. The fractured surface of a metal or alloy often affords a general guide to its properties and adaptability to various uses. It is best obtained by nicking a bar with a chisel, gripping it in a vice, and striking it with a hammer. In this way either the brittleness or the toughness is shown by the angle through which it bends and the force required to break it. When broken, any great want of homogeneity is shown by the irregular appearance of the fracture. The bar is said to be *crystalline* when it is made up of visible crystals.

When the crystals are so small that they cannot be seen by the unaided eye the fracture is said to be *granular*; occasionally the grains are so minute that they present merely a silk-like sheen, as in hardened steel and wrought copper, when it is termed a *silky fracture*. Wrought iron, when broken, shows a fibrous fracture, due to threads of enclosed slag. Usually a coarsely crystalline or granular fracture in a metal indicates less satisfactory working properties than one of the same class in which the fracture is finer; and a fibrous metal is likely to be tough because the presence of the fibre is an indication that the metal was malleable enough to be rolled. The size of the grain is often largely dependent upon the temperature at which a metal was cast and upon the subsequent mechanical and thermal treatment that it has received.

A metal which has been poured into a mould at a temperature far above its melting point is generally coarser than one poured at a lower temperature. Rapid cooling also tends to produce a fine grain. Hammering a metal produces a finer grain, and overheating produces a coarser grain. Very hard and brittle metals often break with a glass-like, lustrous, and curved structure, termed *conchoidal fracture*.

Continued

Group 6 ARMY & NAVY 1 Following on CIVIL SERVICE from page 3743	

THE PRIVATE SOLDIER

The Army as a Career. The Various Branches of the Service. Standard for Recruits. Artificers. Duties and Pay

By C. DUNCAN CROSS

As a means to amassing a fortune the Army is not to be recommended. The purpose of the SELF-EDUCATOR, however, is not to teach merely how to make money; it is to direct its readers toward the walk of life which affords a livelihood and at the same time offers an occupation which agrees with their tastes. That the Army, for itself, is an allurement to many a young man will not be denied; and though to-day it is less true than in former times that every drummer-boy carries in his knapsack the baton of a field-marshal, it will be our business to show how a young man of spirit can earn a livelihood with honour to himself and with benefit to his country.

Physical Standards. Any young man of good character and of good health may offer himself as a candidate for the Army. The standards of height and chest measurement vary with each arm of the Service. Of the most important branches they are as follow, though the figures are liable to alteration according to the supply of and demand for recruits.

	Arm of Service.	Height.	Age.
		ft. in. ft. in.	
CAVALRY	Household Cavalry	5 11 – 6 1	18—25
	Cavalry of the Line: Under 20	5 4 – 5 7	,,
	,, ,, Over 20	5 6 – 5 8	,,
ARTILLERY	Gunners, R.H.A.	5 7 – 5 10	,,
	,, R.F.A.	5 7 – 5 10	,,
	,, R.G.A.	5 8 and upwards	,,
	Drivers, R.H.A.	5 4 – 5 7	,,
	,, R.F.A.	5 3 – 5 7	,,
	Artificers and Tailors	5 4 and upwards	,,
ENGINEERS	Sappers and Pontoniers	5 4 ,,	,,
	Boatmen	5 4 ,,	,,
	Shoemakers, Tailors, Bricklayers	5 5 ,,	,,
	Drivers	5 5 – 5 7	,,
	Telegraph, and Railway Reserve	5 5 and upwards	19—30
INFANTRY	Foot Guards: Under 20	5 7 ,,	18—25
	,, Over 20	5 9 ,,	,,
	Line	5 3 ,,	,,
	Army Service Corps	5 3 – 5 6	,,
	,, Drivers	5 2 – 5 4	,,
	Royal Army Medical Corps	5 3 and upwards	18—28
	Army Ordnance Corps: Armourers and Machinists	5 4 and upwards	21—30
	Others	5 3 – 5 5	,,
	Post Office Corps	5 4 and upwards	19—30

Chest measurement is also taken into consideration. The body must be well nourished, and, above all, there must be a range of expansion between the chest contracted and expanded of not less than two inches.

Weight has something to do with the matter nowadays, particularly in the cavalry. The Army no longer requires heavy men, who make a good show but tire out their mounts. So, except in the case of the Household Cavalry, a heavy man is not accepted. Therefore, if a man scales over 150 lb. he had better turn his mind to some other branch of the Service. The same is true of the artillery. Big, strong men are required for gunners, but small men for drivers.

Skilled Tradesmen. In the Army, as in the Navy, there are openings for skilled tradesmen who desire to combine their skill with the pursuit of an adventurous calling.

In the cavalry and artillery, men who have any knowledge of horses are always welcomed; and a man who is willing to apply himself may hope for a ridingmastership, which carries with it an honorary lieutenancy. In the Royal Engineers there are openings for any trade which is needed by an army in the field. In the Army Service Corps are to be found men conversant with trades which are useful for the supply of an army in the field. The Army Ordnance Corps calls for many men of miscellaneous trades which have to do with the repair and upkeep of military works and stores. Lastly, for men with a certain professional leaning there is the Royal Army Medical Corps, in which an able man may always make his way.

For those who have no particular trade but a liking for soldiering, there is the infantry. The pay is not so high as in the more skilled branches of the Service, but, on the other hand, the work is less arduous.

In any case, let us impress upon the intending recruit one thing. The Army is a good master but a bad servant. That is to say, that the man who joins the Army as he would join a business, intending to make it his livelihood, allowing nothing to deter him from success, will find the Army a good place to live in. On the other hand, the man who joins the Army for want of something better, who shirks his work, and who means to get out of it as soon as possible, will find himself at the end of his short service little better off than when he started. So we would say, having made up your mind to be a soldier, join young, and make the Army your home. With close attention to business you will soon reach a responsible position, and will retire on a handsome pension, with a good prospect of civil employment in addition. With luck you may live to wear the sword of an officer.

Promotion. It will be evident that no fixed dates can be laid down in which a man may expect promotion to a certain rank, the varying

conditions of service, and the element of luck which enters into the calculations, preventing such an attempt. A few general remarks as to possibilities may, however, be ventured. In a Line regiment of infantry a smart man with fair education may expect to gain his first step in from six months to a year from the time he becomes a private. His second step, with the corporal's stripes, may be hoped for in another six months or a year. As corporal he will have to serve another three or four years before he gains his sergeant's stripes; and beyond that probably another two years or more before reaching the rank of colour-sergeant. In the Foot Guards and the Household Cavalry, where a higher standard of efficiency and smartness is demanded than in the Line, this time may be considerably extended. In the skilled branches of the Army—the Engineers, the Army Service Corps, the Ordnance Corps, or the Royal Army Medical Corps, where the proportion of non-commissioned officers to men is greater, and individual responsibility has to be accepted to a greater extent, the prospect of promotion is very good to the skilled man; and there are many openings as storekeeper, foreman of works, and so forth, with good pay and comforts to those on the watch for them.

A Commission. The hope is sometimes held out to intending recruits that they may work their way to a commission. In time of war a man may be, and often is, promoted to a commission for gallant conduct or special service in the field. In peace time, however, it is extremely rare for a man to be promoted from the ranks unless he has a first-class education, backed by a certain amount of money and influence. The most that a young man should expect, therefore, is to reach warrant rank and, perhaps, an honorary lieutenancy; but, on the other hand, he should always be ready to grasp a chance which will lift him beyond, for it is true in the Army, as elsewhere, that the best men are bound to come to the front, and that the so-called lucky man is merely the man who has prepared for the opportunity and has grasped it when it has arrived.

With these general observations we will pass directly to the conditions of the Service and the method of entering it.

How to Join the Army. Facilities for joining the Army lie around on every side. To begin with, there are the main recruiting stations in London, the head office near Charing Cross, and the other branch offices. In the country and the provincial towns a man can be enlisted at every barracks of Regulars or Militia, and every sergeant-instructor of Volunteers is ex-officio a recruiting agent, who will be pleased to give information, advice, and assistance to a young man who desires it. Last of all, and this is not so generally known, every soldier serving in his Majesty's Army is a recruiter who will take charge of the young man, will convey him to the nearest point where he may join, and will draw the sum offered by the Government to its agents for the body of a recruit. Certain regiments—the Guards, for example—have special recruiting stations and special methods of attracting recruits; but a man can present himself at any of the before-mentioned stations, and, if he come up to the Guards' standard, he will be drafted there.

Choice in the Service. The choice of the arm of the Service to which he will belong will be a matter of anxious consideration to the recruit. To the average man the more showy branches of the Service will appeal most—the cavalry or the artillery; but unless he has some acquaintance with horses these are not altogether to be recommended, and it should never be forgotten that when the day's work is done the horse or the gun has to be cleaned up, whereas the infantryman has only himself to look after. A man is allowed to choose which arm of the Service he prefers, but unless he has some special connection with a regiment he must accept any regiment to which he may be drafted as the good of the Service demands.

The periods of service vary according to the arm of Service, as is shown in this table:

—	With Colours. Years.	In Reserve. Years.
Household Cavalry	8	4
Cavalry of the Line	7	5
Royal Horse and Field Artillery	6	6
Royal Garrison Artillery ..	8	4
" " " Artificers	3	9
Royal Engineers, Drivers ..	2	10
" " " Sappers ..	3	9
" " Mily. Mechanists	12	0
Foot Guards	3	9
" " Bandsmen ..	12	0
Infantry of the Line	7	5
Army Service Corps:		
Drivers	2	10
Others	3	9
Royal Army Medical Corps	3 or 1	9 or 11
Army Ordnance Corps ..	3	9
Machinery Artificers and Armourers	12	0

The Recruit. At the recruiting station the young man is measured, is put through a severe medical examination, which embraces physical condition, eyes, and teeth, and, should all be satisfactory, he swears the oath of allegiance required by his King, and is drafted either to the depot, or in some cases to his own regiment.

Army Pay. The question of pay is complicated by the fact that regimental pay varies in the different arms of the Service. A table showing the pay of the principal branches of the Army is given on the following page.

In addition to this it must be remembered that all these men have allowances and additional pay. The infantryman, for instance, drawing 1s. a day regimental pay, draws an extra 2d. per day for up-keep of kit, and 3d. a day for messing, after six months' service. After two years (if he has extended his service) he draws an extra 3d. or 6d. a day, as proficiency pay, according as he is classed I. or II.

The deductions are 3d. a day for extra messing and the cost of his washing—say in all 2s. 6d. per week—as an outside figure for the infantryman. The deductions in other corps—the

DAILY REGIMENTAL PAY OF WARRANT OFFICERS, N.C.O.'S, AND MEN									
	Cavalry.		Artillery.			—	Infantry.		—
Rank	Household Cavalry.	Line Cavalry.	Royal Horse Artillery.	Royal Field Artillery.	Royal Garrison Artillery.	Royal Engineers.	Foot Guards.	Line.	Army Service Corps.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Regimental Sergeant (Corporal) Major	5 10	5 4	6 0	5 10	5 10	6 0	5 2	5 0	5 6
Bandmaster	5 6	5 6	6 0	6 0	6 0	6 0	5 0	5 0	—
Qr.-master-Sgt. (Corp.-Major) Battery Sergt.-Major.. ..	4 6	4 4	4 4	4 2	4 2	4 6	4 0	4 0	3 9
Sergeant (Corporal) Maj. Instructor	3 3	3 3	—	4 0	4 0	—	3 3	3 3	—
Squad. Sergt.-Maj. (Corp.-Maj.)	4 6	4 4	—	—	—	—	—	—	—
Company Sergt.-Major ..	—	—	—	—	4 0	3 9	—	—	4 3
Farrier Quartermaster-Sergt. (Corp.)	4 3	4 0	4 5	4 3	—	3 9	—	—	4 3
Wheeler Quartermaster-Sergt.	—	—	3 11	3 9	—	—	—	—	4 3
Collar-Maker and Saddler Q.M.-Sergt. (Corp.)	4 0	3 8	3 11	3 9	—	—	—	—	4 3
Sergt. (Corp.) Trumpeter, Sergt. Bugler	3 2	2 8	3 4	3 2	3 2	4 6	2 6	2 4	—
Sergeant (Corporal of Horse)	3 0	2 8	3 4	3 2	3 2	3 3	2 6	2 4	2 7
Sergt. (Corp.) Farrier and Carriage Smith..	3 4	2 10	3 9	3 7	—	3 3	—	—	—
Kettle Drummer, Sergt. Drmr.	2 4	1 9	—	—	—	—	2 6	2 4	—
Col.-Sergt., Corporal Artificer	—	—	—	—	—	2 6	3 8	3 6	2 6
Corporal	2 8	2 0	2 8	2 6	2 6	2 6	1 9	1 8	2 0
Bombardier, Second Corporal	—	—	2 5	2 3	2 3	2 2	—	—	1 9
Collar-Maker, Wheeler, Saddler, Artificer	2 4½	1 9½	2 8	2 6	2 6	—	—	—	—
Shoeing and Carriage Smith..	2 3	1 8	2 2	2 0	2 0	2 0	—	—	1 2
Trumpeter, Bugler, Drummer, and Fifer	1 11	1 4	2 0	1 2½	1 2½	1 1½	1 2	1 1	1 2
Gunner, Sapper, Private, on Enlistment	1 9	1 2	1 4	1 2½	1 2½	1 1½	1 1	1 0	1 2
Driver	—	—	1 3	1 2½	1 2½	1 1½	—	—	1 2
Boys (all arms)	0 8	0 8	0 8	0 8	0 8	0 8	0 8	0 8	0 8

Household Cavalry particularly—are heavier. On the other hand, deductions from one cause or another should never exceed 3s. 6d. per week in any corps, so that we must revise our figures somewhat. A private, after two years' service, would receive, according to his class:

WEEKLY PAY—WITH ADDITIONS—OF A PRIVATE SOLDIER					
Cavalry.		Artillery.		Infantry.	
Household	Line	R.H.A.	R.F.A.	Guards	Line.
s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
16 11 to 18 8	12 10 to 14 7	14 0 to 15 9	13 1½ to 14 10½	12 3 to 14 0	11 8 to 13 5

Soldiers enlisted as Boys draw proficiency pay on attaining the age of 20.

In addition to these rates, men of certain corps draw extra duty pay, working pay, engineer pay, and corps pay, at rates varying between 3d. and 2s. per day, according to their qualifications. When we consider that this is in addition to free board and lodging, it will be admitted that for a steady man the Army is not so badly paid as many trades outside.

Duties and Discipline. At first the work is very dull to the recruit, who is harassed, too, by the numberless restrictions of a discipline which is new to him. All the time, however, he is under constant surveillance. If he proves himself apt at drill, respectful to his superiors, clean and sober, he will gain the confidence of his officers and the respect of his fellows. In from four to six months this phase of his instruction will have ended, and if at a depot he will be drafted to his regiment; or if with his regiment, will find himself on an equal footing with the trained men.

It is now that the young soldier should settle on a career. He can elect to be an officer's servant, in which case his military duties will be considerably lightened, and he will receive an addition to his pay from his master. On the other hand, this leads nowhere, and is hardly a career for an ambitious young man.

Another avenue is to become a clerk in the orderly room; but this, though it involves certain advantages and relief from duty, is an indoor life, and will probably fail to satisfy the thirst for glory which every soldier should have.

Now, we shall suppose that our private decides to fight his way through the ranks as a plain soldier. His good behaviour as a recruit has merited approval already, and a continuance cannot fail to attract the notice of his colour-sergeant. Of all virtues that appeal to a soldier the one most sought is smartness on parade. This, combined with readiness in thought and action, the strictest sobriety and civility, will bring its own reward in due course when the private is recommended for his first step.

Continued

WOOD JOINTS AND FASTENINGS

Advantages of Building Up. Screwed and Nailed Joints. Glued Joints. Butt, Dowelled, and Tongued Joints. Fitting, Securing, and Subsequent Treatment

By WILLIAM J. HORNER

THE jointing and fastening of a number of pieces together is necessary in practically all woodwork, and it is chiefly in the knowledge of how to do this efficiently that the woodworker's art consists. The fitting of separate pieces is often more necessary in timber constructions than it is in those of metal, which material, being destitute of "grain," is practically as strong in one direction as another. Neither is it liable to shrink and warp as wood does, and it is often as strong or stronger when in one solid piece than if built up of a number of parts. Wood is really strong only in the direction of its fibres—that is, it will stand a great deal of tension, compression, bending, or shearing stress across its grain—but is very weak indeed if subjected to stress in line with the fibres. It is necessary, therefore, to strengthen it in its weakest direction by connecting it to pieces with their grain at right angles to it, or by metal attachments in the form of bolts or straps. In the case of pieces of wood of considerable width, this stiffening across the grain is necessary even if it is to be subjected to no actual stress of any kind, because, if it is not so stiffened, it will warp.

Joints in Woodwork. Joints in woodwork, if properly made, are not an element of weakness, but in most cases quite the contrary. The chief objection to joints, in fact, is the trouble of making them. Across the grain, the greater the number of pieces used in making up a given width the less trouble is likely to arise subsequently from shrinkage or cracking. End grain joints can always be made if necessary, and be as strong as the solid wood; but except for very great lengths, it is simpler and better to have the wood in one piece without joints. Accurate fitting is essential in all joints, not only for appearance, which in many cases might be disregarded, but primarily for strength.

There is much variety in the forms of joints that can be employed even under almost any given circumstances, but there is usually only one form that is the best possible for each particular case. The nature and direction of the strains to which the two or more members will be subjected have to be considered in deciding on the most suitable form, and also the amount of work in making it, and the desirability or otherwise of permanence and good appearance.

Joints with Screws. Both screws and nails are very commonly employed in all woodwork, sometimes in conjunction with glue, but more frequently alone. In most cases they are more reliable than glue; and another reason why they are often preferred is that there is then no waiting for glue to dry. Screws are superior to nails in holding power, but the chief consideration which favours their use is that they can easily be withdrawn if necessary without injury to the work, and they can also be inserted without the jar to delicate work that nail driving involves. Nails, however, are often quite as satisfactory from these points of view, and have the advantages of being more quickly inserted and cheaper.

Screw Holes. Fig. **118** shows in section a screw in place holding an upper piece of wood to a lower. The hole for the screw is bored entirely through the upper piece, and is of a diameter that permits the screw to slip easily into it up to the head. In neat work the bevelled enlargement for the head is countersunk with a suitable bit, but in many cases, especially if the wood is soft, the screw is merely tightened down into the bored hole until the head is flush, or slightly below the surface. The objection to forcing it without countersinking is that it slightly twists and compresses the grain around the head. If it be desirable to sink it to a considerable depth, a centre-bit hole is bored for the head to sink into [**119**], and generally this hole is plugged after the screw is home. Often screws are sunk in this way solely to conceal the head by plugging, the grain of the plug running the same way as that of the wood into which the screw is inserted; but occasionally it is done because the stuff is very thick and it is desired to use a comparatively short screw.

The hole in the lower piece of wood is always bored smaller than the threaded portion of the screw, and shorter than the distance to which the point will penetrate. Its precise relation to the size of the screw depends on the character of the wood, a larger hole being required in hard wood than in soft wood. The ability of the wood to resist the splitting action of the screw must be considered also, a small, short-grained, narrow piece being much weaker than a long piece of large area. In the latter case, in fact, if the wood be soft and the screw not large, it is not necessary to bore a hole at all in the under piece of wood, but merely to give the screw a tap with the hammer to start it, and run it in with the screwdriver. To ensure a close joint, a chisel should be passed over the holes in the joint, to remove any splinters.

When screws are inserted in this way, the upper piece of wood is held by the bevelled head, and the lower by the threaded portion of the screw. If the body of the screw be a tight fit in the upper piece of wood, there is difficulty in drawing the joint together as the screw is being tightened. Grease may be used with advantage on both screws and nails to assist them in

penetrating, and it also makes their withdrawal easier at any subsequent period.

When a number of screws have to be inserted, and the left hand is not required for holding the work, the most expeditious method is to use a screwdriver bit in a ratchet brace, making continuous turns with the brace until the screw is nearly home and getting tight, and then using the ratchet movement in short turns to give power. If much force be applied, through not having the hole bored large enough, it is not unusual for a screw to break in hard wood, either at its head, or to twist off near the top of the threaded portion. If one half of the head breaks off, it may be twisted back with pincers or pliers. If the entire head is off it is best to slip the wood off it if possible, and withdraw it from the joint; or if it be broken at the joint, this method may be adopted. If it be necessary to go below either surface to get at it, the wood must be cut or punched away until a grip on it can be obtained. If this be objectionable, it is best to leave it embedded, and insert another near it. Very tight screws can often be loosened for withdrawal by a few blows delivered by a mallet on the end of the screwdriver. This also may be carried far enough to make the screwdriver cut and penetrate deeper into the head, and so obtain a better hold. Care should be taken not to let the screwdriver slip and damage the head when trying to turn it, because the more a head becomes worn the less chance there is of being able to turn the screw.

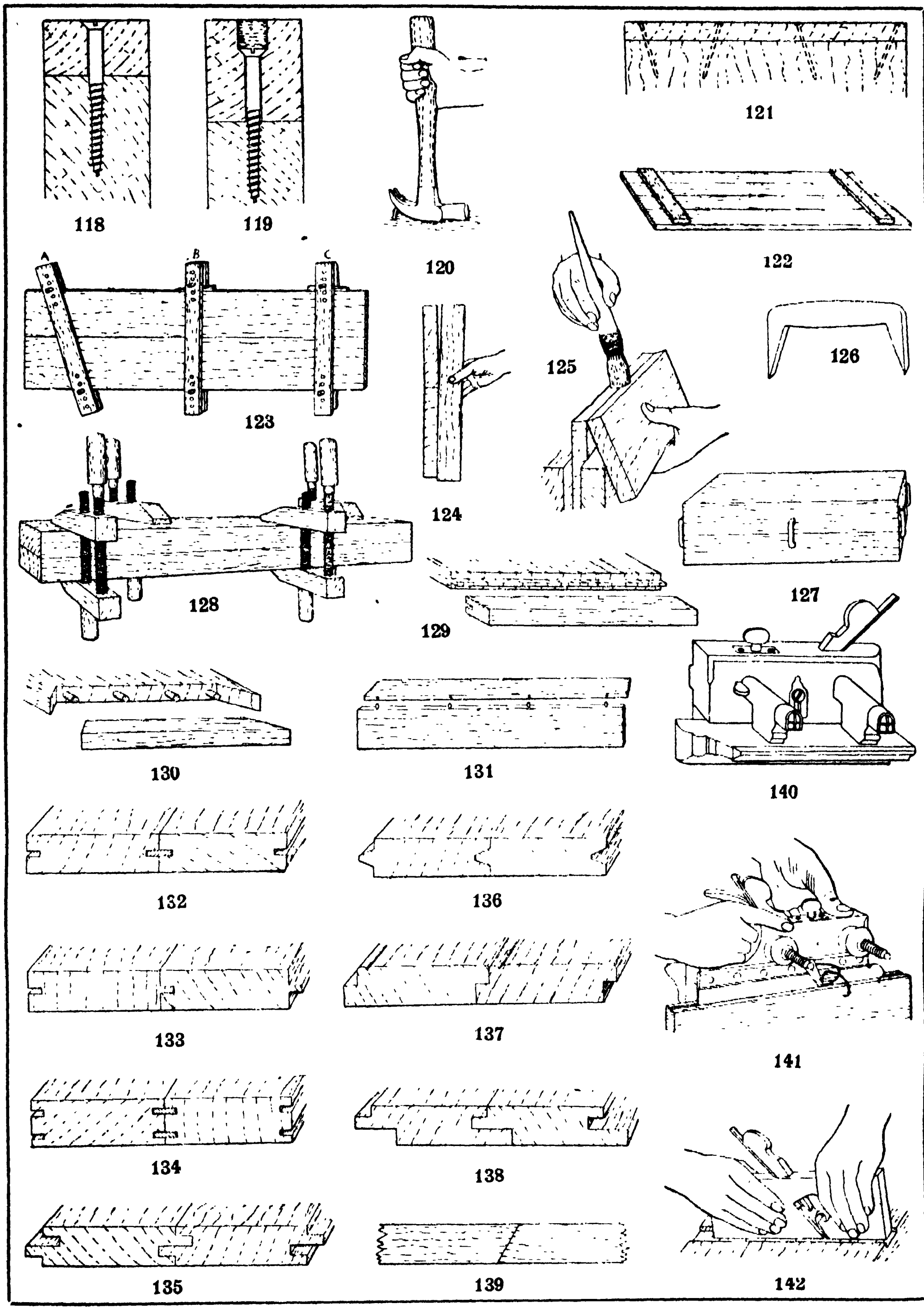
Joints with Nails. Nails are simply driven in with a hammer, and holes are bored for them only when there is a risk of their splitting the wood. They are withdrawn with pincers, or the claw of a claw hammer [**120**], but in either case it is necessary to have the head standing a little above the surface of the wood to obtain a hold on it. This, however, is generally the case when a nail has to be withdrawn, because if it bends or goes out of the direction required, the person who is driving it sees before it is completely home that it will have to come out again. When nailed work has to be taken apart, the nails are not usually withdrawn first, though there are patent appliances for withdrawing them, but the wood is prised or knocked apart, and the nails removed after if required.

Neither screws nor nails hold so well in end grain as in side or " plank way " of the grain, and consequently they are generally put closer together, and often driven at angles, as in **121**, or a greater length is selected than would be used in side grain. The spacing is decided by the nature and size of the work and the strength required. When inserted in a line in side grain at short spaces apart, the number of holes or breaks in the continuity of the grain weaken the wood considerably, and render it very liable to split along the line of nails. If there be not more than an inch or so of width in which to drive them, as in the edge of a box, this cannot be avoided, but in a piece as wide, for instance, as the battens shown in **122**, a double line would be inserted rather than one line down the middle, the spacing of each line being about doubled, and the screws or nails *staggered, chequered*, or placed zig-zag. This throws them out of line in the under piece of wood also, and, moreover, one line of nails or screws down the middle of a wide batten would nullify the advantage of width in the batten, rendering it of no more value than a batten just wide enough to take the screws without splitting. Another undesirable feature would be the tendency of the edges of the batten to curl up from the surface unless held down by nails near the edges.

The Butt Joint. The simplest form of joint possible is a *butt*, in which two flat surfaces are brought together and are held by glue, nails, screws, bolts, battens, fish-plates, or other means; or are not actually connected, but merely abut together, and are held in that position by being fastened separately to some other part of the structure, as, for instance, when flooring boards are laid side by side and nailed to the joists upon which they rest. This is the form of joint usually employed when glue is used to unite pieces of wood side by side in building up either a greater width or greater thickness. If the joint be well fitted and properly glued, it is practically as strong as the solid wood, but it is suitable only for the side or plank way of the grain. On end grain, glue is almost useless, and, owing to shrinkage and swelling of the wood across grain, glue cannot be used for uniting pieces crosswise.

As a close fit everywhere is essential in a glued joint, the simplest way of obtaining this is to plane both surfaces absolutely true. In small joints it is a very simple matter to plane them to a fit; in larger ones considerable skill is required; and in the case of very large surfaces, where the material is so large, or comparatively thin, as to be pliant, an absolutely true surface is not so necessary, but the joint is brought close everywhere by clamping. In the making of long edge joints also, the surfaces may purposely be planed either very slightly hollow, or rounding lengthwise, preferably the former, so that they will need clamping only at the open part, and when this has been squeezed together the other parts will have bound themselves tightly. If left clamped in this way for about a day, until the glue is thoroughly hard, the clamps may then be taken off without fear of the joint opening again. Glued joints, except the very smallest, should always be clamped, or otherwise pressed tightly together until the glue is set.

Fitting Glue Joints. In making long edge joints of the character shown in **123**, the two pieces of wood are generally held side by side in the vice and planed together. This makes it easier to get the edges square with the faces, or if there be a slight inclination to one side, they will counteract each other when the joint is fitted together. The try square is used to see that the edges are approximately square, but the final fitting is done by trying the two pieces together and examining the joint. If open places be visible anywhere, the close parts must have shavings removed from them until there is close contact everywhere, the exception, of course, being when the joint



JOINTS IN WOODWORK

118. A screw inserted in the ordinary way **119.** A screw countersunk below the surface **120.** Drawing a nail with a claw hammer **121.** Nails driven at angles **122.** Boards held together by battens **123.** A glue joint cramped **124.** Testing an edge joint from the face **125.** Applying glue to a joint **126.** A dog **127.** A glue joint held by dogs **128.** A joint held by handscrews **129.** A cleat tongued on an end **130.** A mitred cleat dowelled **131.** A dowelled joint **132–139.** Tongued and other forms of edge joints **140.** A plough **141.** Using a plough **142.** Using a rebate plane

is purposely being made open at the middle or ends to be closed in clamping; but this can be done only in large joints. If the pieces fitted together be very wide, as in **123**, it will be important that they shall be as nearly as possible in line when glued, and therefore a mere square test on the joint should not be relied upon, but a straightedge should be tried across the entire width [**124**], when the pieces are together in fitting the joint. A very slight inclination on the joint will throw the faces considerably out, and necessitate a great deal of planing and reduction in thickness to get them true after the joint is glued. This, therefore, is a point which must not be lost sight of when the attention is engaged in making the joint as close a fit as possible. Very slight differences in the angle of the joint can easily be made by keeping the plane to one side on the edge as it travels along the joint, so that the middle part of the iron where the shaving is thickest may be at one side, and the side of the iron where the shaving tapers to nothing may be at the other side, thereby cutting a shaving of unequal thickness and altering the angle of the joint.

Edge joints are usually planed with the wood in the vice, and the plane used as shown in **102**, but sometimes short joints, not exceeding 2 ft. or 3 ft., are planed with the wood on a shooting board, as in **101**, the advantage of the latter method being that the edge cannot then be otherwise than approximately square. When the wood is too long to be held properly in the vice alone, the front end only is gripped by the vice, and the back supported at the same level.

Gluing and Cramping. The glue is applied as quickly as possible to both pieces, which are held as shown in **125**. The glue should be as hot as possible, and the joint closed before it has time to get cool. In gluing a long joint two men are necessary, one at each end, to rub superfluous glue out by sliding the upper piece on the lower and to see that the sides and ends are flush when the rubbing ceases, and also to assist each other in cramping or driving dogs without loss of time. Small joints can easily be manipulated by one person.

Either dogs [**126**] or cramps [**123**], or both, may be used for holding a joint together while the glue is setting. Cramps are more powerful and decidedly better for large joints. For edge joints where the cramps have to span a considerable width, bar cramps tightened by a screw, or various forms of shop-made cramps tightened by wedges are used. A simple form suitable for cramping almost any width is shown in **123**, A, B, and C. It may be tightened merely by knocking it diagonally across the joint until it holds (A), or by driving a wedge between the pin and the edge of the board (B), or more securely still by driving two wedges in opposite directions (C). Numerous other forms of cramp are used in which the extension is fixed to suit work of fixed size, such as doors, that are constantly being made, but the means of tightening is nearly always the wedge.

Joints with large surfaces, such as **127** and **128**, are made by planing the surface of one of the pieces perfectly true, and then fitting the other to it. Square, straight-edge, or winding strips are used in the preparation of the first piece, and sometimes in roughing down the second, but the final fitting is done by trying the two pieces together and examining the joint round the edges, especially at the corners, to see whether it is in close contact everywhere. The sense of touch may also be employed to find whether there is any rocking or unequal bearing between the two pieces. A very common method is to rub chalk all over the surface of the joint of the piece that has been planed true, and then rub the surface of the other piece on it. This transfers some of the chalk to the second piece and shows all over the surface just where contact exists and where not, and the joint can thus be very expeditiously brought to a fit by planing from those portions where the chalk marks indicate the high places. This is a very satisfactory method of fitting any surfaces to each other, whether for glue joints or not, or whether the surfaces be flat, curved, or irregular in shape.

For cramping joints of broad surface, and wood of comparatively shallow depth, handscrews are the most suitable, and are more commonly used for glued joints than any other kind of cramp [**128**]. They are not suitable for edge joints because their extension is too limited. They can be screwed up to give a uniform parallel grip, or, if the work requires it, the pressure can be increased or diminished at point or back by relaxing one of the screws and taking up the slack with the other.

Glue. Glue is stronger when freshly melted than after it has been reheated or kept hot for a long period. The proper way to make it is to break it up into small pieces and soak it in cold water for several hours to soften. Then put it in the glue-pot and heat it, adding enough water to cover it. Glue is always heated in a double pot, the inner containing the glue, and the outer the hot water. Water is used to thin the glue down to the required consistency. This thinning depends to some extent on the kind of work for which the glue is required. For small work it should be rather thick, for large joints it should be thinner. It is sometimes more convenient to use liquid glue than to melt glue for use, but in shops where large quantities are required the latter method is preferred.

When melted glue is used, it should be applied as quickly as possible while hot, and in gluing large joints in a cold atmosphere it is best to warm the surface of the wood first, so that the glue shall not be chilled and commence to set before the operation can be completed. It should be applied to both surfaces of joints, and then the endeavour is to rub and squeeze as much as possible of it out and to bring the woo[d] into contact with no very appreciable film of glu[e] between. While doing this the surfaces shou[ld] never be separated, but merely slid to the exte[nt] of 2 in. or 3 in. over each other, the distance depending on the size of the joint. When this is done properly the two pieces will rapidly become very difficult to slide, and they should then be adjusted exactly in relation to each other, and

cramped. If the pieces are allowed to separate slightly while rubbing them together, especially at the finish, the joint will not hold satisfactorily. In that case it is generally better to take them apart, wash the glue off and apply fresh, and "make the joint" again.

The Cleat or Batten. Instead of gluing boards edge to edge to make one wide piece, they may be held together by laying them edge to edge without glue, and screwing or nailing other pieces of wood, termed *cleats* or *battens*, across them [122]. This method is sometimes adopted in addition to gluing, but the battens are then more for the purpose of keeping the surface of the wide piece from curving or splitting than for holding the joints together. Joints held by battens are rather a rough class of work, though satisfactory as far as strength is concerned. When boards are battened together without gluing, the joints open slightly if the wood shrinks, but in battened work this is usually not objectionable, and moreover, if the joints could not separate, the wood would probably split in places. When battens screwed on the face, as in **122**, are objectionable, either on account of appearance or because they are in the way, a neater but not quite so strong a method is to tongue them across the ends [**129**], as is often done in drawing-boards. A refinement of this method again is to mitre the corners [**130**] so that no end grain is exposed. The objection to bringing the end grain of battens flush with the width of the board is that when the board has shrunk the ends project beyond. Battens attached to the face as in **122** are always cut slightly short of the full width.

Dowelled Joints. Although, as already stated, a plain side grain glue joint properly made is practically as strong as solid wood, there are cases where it is advisable to make the joint of more complicated form, while still using glue as the means of holding. In edge-glued joints the two chief variations from a plain flat surface are the *dowelled* joint [**131**] and the *grooved and tongued* joint [**132**]. The dowelled joint is used in many ways in addition to an edge joint like that shown. It is very commonly adopted in end grain where glue has little holding power. Dowels are shown in the end grain of the mitred cleat joint [**130**]. Very often tenons are preferred in such a case. The main idea in using dowels, however, is not so much to hold the parts together as to prevent side movement, though, if glued well, their assistance in holding together is considerable. As long as glue holds, side movement is impossible, but glue cannot always be trusted. Its quality varies, and in damp situations it is not of much value. A glued joint at its best is as strong as solid wood. Some men even assert that it is stronger. But nevertheless glue joints sometimes break, often tearing away some of the wood on either side, but with the main break through the joint. In the case of a joint subjected to a bending or shearing stress which would tend to split the timber, dowels extending a short distance on each side of the joint would prevent the joint from breaking; or, if the glue failed, the joint might separate by shrinking, but the parts would still be kept flush with each other by the dowels. One disadvantage of a dowelled joint is that it is not easy to make a thoroughly satisfactory glued joint of it, because rubbing the parts together is impossible, and the dowels are a slight hindrance in getting it quickly together as soon as the glue is applied. Extra force is therefore advisable in cramping it.

Dowels. *Dowels*, or *dowel pins*, are round rods of hard wood. They are usually employed only in narrow joints and on small surfaces. The joints are fitted in the ordinary way, and then the centres of the dowel holes are carefully marked opposite each other in the joint on each of the pieces. These centres must exactly correspond in each half, or trouble will be experienced in getting them together. The two pieces are generally placed side by side with their jointed faces upward, and lines are scribed across each at the positions where dowels are to be inserted. Then a gauge is set to about the centre of the thickness of the wood, and longitudinal marks gauged from the same side of each piece. The intersection of these lines indicates the centres of the dowels. Another method is to lay ordinary pins in suitable positions in the joint and to press the parts together in correct position, thus obtaining corresponding impressions of the pin heads on both pieces, these impressions serving as centres on which to bore the dowel holes. The dowel holes are then bored with a centre-bit of a size which permits the dowel to be driven in a tight fit. The dowel pin is then driven in with a little glue in each hole of one of the pieces, and sawn off 2 in. or 3 in. above the surface. Care must be taken to bore the holes in the other piece amply deep enough to receive the projecting dowels. Sometimes instead of entering only 2 in. or 3 in., dowels are put entirely through, thus stiffening and preventing the wood from splitting. Dowels may be purchased ready made, but if wanted only occasionally they can be planed in an angle board and sometimes are driven through a hole of the correct diameter in a piece of iron or steel plate. It is important that they fit the bit hole tightly, but it is not essential that they should be perfectly cylindrical. Some men prefer them simply planed with a series of flats round their circumference. This tends to keep them from turning, and prevents them from being an air-tight fit and consequently troublesome to insert.

The Tongued Joint. The *tongued joint* [**132**] is variously known as *ploughed and tongued*, *tongued and grooved*, *grooved and feathered*, or *matched*, the last-mentioned term applying only to boarding with tongues worked out of the solid [**133**]. Edge joints of this class are more commonly employed in carpentry and joinery than either the plain, square butt joint, or the dowelled joint. They are not much more troublesome to make than the dowelled joint, and for most purposes are decidedly superior to it. The tongued joint may be put together either with or without glue. Its two chief advantages are, that no

matter how much the wood shrinks, the tongue prevents light or dust from passing through what would otherwise be an open crack between the boards, and also it keeps the boards flush with each other throughout their entire length more effectually than dowels at intervals could. The tongues, or feathers, are thin strips of wood sawn to fit the grooves, generally with their edges convex to facilitate insertion. Usually they are cut with their grain running the same way as the boards; but some workmen prefer them with the grain crosswise, or diagonally. Sometimes also, hoop iron is used instead of wood, so that they can then be made very thin, with, at the same time, a gain of strength both to themselves and to the boards, which do not require such wide grooves. When the grooving is done by hand a plane termed a *plough* [**140** and **141**] is used. In this plane, irons of widths ranging from about $\frac{1}{8}$ in. to $\frac{5}{8}$ in. can be used, according to the width of groove required. These irons can be adjusted to plough to a certain depth and to a certain distance from one side of the wood, the body of the plane acting as a gauge. Irons for planing the tongues are also sometimes used in it, but generally both edges of the boards are grooved and loose tongues put in. Very often when glue is used, the tongue is also nailed into one of the grooves. When a circular saw with a rising table is available, grooves are generally sawn in preference to the use of a plough. Formerly special planes called *match* planes were often used, one to plough a groove, and a companion to it to form a corresponding tongue on the edge of the piece which had to fit it. When such work is done by hand now, ploughs or universal planes are more often employed.

Modifications of the Tongued Joint. The superiority of an edge joint in which the parts overlap and fit into each other is so great that many other forms besides the simple tongue and groove just described are employed. The *double tongue* [**134**] is frequently used for thick joints, or, when machinery is used for cutting them, half a dozen or more grooves and tongues may be made on the edge of a thick board. This latter method is often employed in box-making where thick wood is glued edgewise to make up a given width and afterwards ripped down into a number of thin pieces. There is also the double-tongued joint [**135**] in which both a projection and recess are cut on the same edge of each piece. There is the *bevelled* or *angular tongue* [**136**], in which an easy entrance and close fit are assured by the wedge form of the tongue. Also the *rebated joint* [**137**], in which the edges are cut to form a half lap joint; and there is a modification of this in the *rebated and tongued joint* [**138**]. There is also the *splayed, bevelled*, or *scarfed* joint [**139**], which is more commonly employed for ends than sides of boards, and is then also a *heading joint* All these joints are used for flooring boards and similar work where a number of boards have to be fitted side by side. Where there is no objection to it, a *quirk bead*, as shown in **137**, is employed to make the joint less noticeable if the wood should shrink, and also to improve the appearance.

Rebates are planed with a rebate plane, as shown in **142**. A rebate may be required at an intermediate position as in **142**, or at an end, as in the case of the tongue in **129**. When working across grain it is necessary to run sawcuts to the correct depth before the plane can be used, otherwise the sides of the rebate would be torn and splintered by the plane. If accuracy is desired, the sawcuts are kept to one side of scribed lines, and these are afterwards pared to with a chisel. In planing with the grain, it is not necessary to use a saw, but a strip of wood is generally attached temporarily to the surface to form a guiding edge for the plane. The depth of the rebate is marked with a gauge. A chisel is used for roughing down, and the plane for finishing.

Treatment of Jointed Parts. Unlike exterior surfaces, joints are never finished by glass-papering or other treatment, but are brought to a fit by the cutting tools only, and put together in that state. When properly fitted thus, further work on them would not only be superfluous, but sometimes detrimental, by rendering edges less sharp, and consequently making the lines where surfaces meet more apparent when the parts are together. It is always advisable to have joints a close fit at the exterior, even if this be obtained by undercutting in other parts. A slight amount of undercutting to ensure a close fit at the outside is nearly always permissible, and as a rule is not a weak feature in a joint. Similarly, inner projections, such as dowels and tongues, are invariably kept a little short in their recesses to make sure that they shall not prevent the other parts from coming together as closely as possible. In the tongue, for instance, in **132**, and the other examples that follow it, about $\frac{1}{16}$ in. of space would be allowed between the bottom of the groove and the edge of the tongue. In a rebated joint like **137**, no slackness could be allowed anywhere, unless in cases where one face were hidden and very close joints were required on the other. In thick stuff jointed in this way, slight undercutting might be practised on the edges, but with a beaded edge it would never be necessary.

Parts which have been glued, or otherwise secured together, nearly always require trimming and reducing slightly, to make their surfaces flush, and true with each other. It is simpler to do this after they are united than to attempt to join them absolutely flush, for none of the usual methods of fastening permit of very delicate adjustment of parts. In neat work also, a general cleaning up with a plane is necessary after the parts are together, because surfaces often get bruised and soiled in handling, and pencil-marks, made to show the position of parts in relation to each other, have sometimes to be removed.

Continued

ANALYSIS OF COLOUR

Crystallography and its Lessons. Light Waves and Theories Regarding them. The Work of Great Men in the Study of Light Phenomena

Continued from page 3731

By Dr. C. W. SALEEBY

Light and Crystals. There is a deeply interesting branch of science which is known as *crystallography*—the study of the form and construction of crystals of all kinds. In the attempt to cover the great fields of physics and chemistry, in this and its companion course, we have been able to spare no space at all for this subject, interesting though it be. But a crystal is made up of molecules, and we cannot question that the shape of the crystal depends, in some way, upon the shape of its molecules. In the course on Chemistry we have had occasion to discuss the work of Pasteur upon the two kinds of tartaric acid, and there we saw how the shape of the molecules must be associated in our minds with their peculiar behaviour in relation to light. We must now study the fashion in which certain crystals act upon a ray of light; and the point which it is desired to emphasise is that we must not regard the behaviour of solutions of tartaric acid, for instance, upon light, and the behaviour of certain crystals upon light, as unrelated, but must constantly associate them in our minds as various instances of the relations between light and molecules of certain shapes.

Ordinary and Extraordinary Rays. The familiar salt known as calcium carbonate occurs in great quantities in Iceland in the particular form which is known as *calcite* or *Iceland spar*. Portions of this substance can very readily be split or cleaved so as to form a transparent crystal, having the shape of a rhomb. Now, in such a crystal, there is a particular direction which is such that the crystal is symmetrical around it, and this is known as the optic axis of a crystal. This optic axis does not pass through any point in the crystal, but, indeed, there are as many optic axes as molecules, and they are all parallel. This fact alone is proof that the behaviour of a crystal, which we are about to study, is really the behaviour of one and all of its component molecules. Now, if we take such a crystal, and look at any object through it, we shall find that everything is double. [See Plate facing page 1201.] In short, when a ray of light passes through a rhomb of Iceland spar, it is split up into two rays, and these two rays differ from each other in the most remarkable way. One of them is known as the *ordinary* ray; it passes through the crystal according to the ordinary laws of refraction, and displays no peculiar characters. But the other ray, which is produced by this process of *double refraction*, has some very remarkable properties of its own, and is called the *extraordinary* ray. In the first place, it does not have the ordinary index of refraction, and, in the second place, we shall find that this ray actually turns round when the crystal is turned round, in such a fashion that it always remains in the same plane with the ordinary ray, and with the optic axis of the crystal. Thus, if we look through such a crystal at writing upon a piece of paper, one of the two images of the writing produced by the double refraction actually turns round as the crystal is turned round.

It is essential that the Iceland spar be prepared for this purpose in a fashion which preserves its natural characters. It must be split in its three natural directions. If it be cut, we shall be apt to find that it has no peculiar characters at all and that no double refraction is produced.

The Extraordinary Ray. What we now require is plainly some device which will enable us to study either the ordinary or the extraordinary ray by itself. This can be done by taking a crystal of Iceland spar, cutting it obliquely so as to form two wedges, and then cementing the wedges together with the substance known as Canada balsam. This particular substance is transparent and has a refractive index which is between the refractive index of the ordinary ray and that of the extraordinary ray of Iceland spar. Hence it is an easy matter to adjust the prism—commonly called a "Nicol"—so that the ordinary ray is totally reflected from the Canada balsam (falling upon it at an angle greater than the critical angle), while the extraordinary ray passes on unchecked.

When we come to examine this extraordinary ray, we find the explanation of the fact that one of the images seen through a rhomb of Iceland spar rotates when the crystal is rotated. We find, in short, that this extraordinary ray consists of polarised light—a term which we have had occasion to use more than once already, and which must now be carefully studied.

A Historic Observation. Double refraction had already been studied by Huygens and by Newton. Reference has already been made to Newton's explanation of it, and his question, "Have not the rays of light several sides, imbued with several original properties?" It was not until 1810, more than a century after Newton's work, that, to quote Professor Tait, "Malus, while engaged on the theory of double refraction, casually examined through a doubly refracting prism of quartz the sunlight *reflected* from the windows of the Luxembourg Palace He was surprised to find that the two rays alternately disappeared as the prism was rotated through successive right angles; in other words, that the reflected light had acquired properties exactly corresponding to those of the rays transmitted through Iceland spar. Even Malus was so imbued with the corpuscular theory of light that he named this phenomenon polarisation,

holding it as inexplicable on the wave theory, and as requiring a species of polarity (akin to the magnetic) in the light corpuscles—a close reproduction of one of Newton's guesses."

It was not long, however, before the true conception was reached, that the ethereal vibrations take place at right angles, perpendicularly, or transversely to the direction of the rays. Professor Tait thinks it probable that the long delay in reaching this true conception is due to the fact that the familiar forms of wave motion are not of this character. We must also note another difficulty. "That a body may transmit waves, in which the vibration is perpendicular to the direction of a ray, it must have the properties of an elastic *solid* rather than of a fluid of any kind. And our experience of the almost entire absence of resistance to the planetary motion seems, at first sight at least, altogether incompatible with the idea that the planets move in a jellylike solid, filling all space through which light can be propagated."

The "Sides" of Light Waves. Transverse waves, then, can have what Newton called *sides*. Furthermore, they cannot interfere with one another, so as to destroy one another, unless their "sides" are parallel; and they cannot interfere at all if their "sides" are at right angles with one another. These statements must be tested by examination of polarised light. But, first, let us insist upon the general statement of the fact, a particular instance of which was discovered by Malus:

"Light reflected from the surface of substances so different as water, glass, polished wood, etc., at a certain definite angle which depends upon the nature of the substance, is found to possess all the properties of one of the rays transmitted through Iceland spar." The angle thus referred to is known as the *polarising angle*. Sir David Brewster further discovered, as a result of a most prolonged and patient research, the law which goes by his name, as follows: "The tangent of the polarising angle is equal to the refractive index of the reflecting substance," or, "when the reflected ray is completely polarised, it is perpendicular to the refracted ray." The light reflected from the sky is partly polarised.

If we use two Nicol prisms together, we can obtain some very instructive results. After passing through one Nicol, light falling on another, turned at right angles to the first, is completely arrested. If a second Nicol, or "analyser," be placed in a similar position to the first the ray passes unchanged; but as the second Nicol is rotated more and more of the light is stopped. When the two prisms are at right angles to each other they are actually opaque, even to strong sunlight.

The Polariscope. The polariscope is an instrument in which we may study the interference of polarised light. Essentially, it consists of two Nicols placed at right angles to one another, but having between them a plate of crystal cut parallel to the optic axis, and, therefore, capable of resolving into two—by double refraction—the polarised, or extraordinary, ray which passes through the first Nicol. In consequence of this resolution the waves can pierce the second Nicol to some extent; in so doing, they interfere with one another, and so produce the coloured rings characteristic of the polariscope. Among other uses, the polariscope has that of enabling us to distinguish between crystals and other bodies more or less resembling crystals. We owe the polariscope to the discovery of Arago, made the year after the observation of Malus. He it was who first discovered that "a plate of any double refracting crystal, such as selenite or mica, when interposed between two similar polarising prisms or piles of glass plates, displays splendid tints, varying in colour with the thickness of the plate and with its inclination to the transmitted beam, and varying in intensity as the plate of mica or selenite is turned round in its own plane." This discovery depends upon the fact, which we have already stated in other words, that two polarised rays cannot interfere with one another unless they are polarised in the same or in parallel planes. After inventing the polariscope, Arago showed by its means that the light of the sky is largely polarised (being none other than sunlight reflected from the contents of the atmosphere), and that the light of the moon and the light from tails of comets shows signs of polarisation—a proof that these bodies shine by light which is borrowed or reflected.

A Great Contributor to Science. François Arago was born in France in 1786. As a mere schoolboy he delighted in the works of the great contemporary French mathematicians, such as Laplace, and he at last left politics and war for science, to which he sacrificed money and every other kind of reward. He died in Paris in 1853 after making a most amazing series of contributions to almost every branch of optics, and also to astronomy by his application of physics to that great science. He also made great contributions to magnetism, and is distinguished as one of the men of science of the highest rank who have done great service to science by their manner of its presentation to the intelligent members of society. A biographer says of him: "He has rendered vastly greater service to astronomy by his popular expositions of it than hundreds of the most assiduous observers put together. Few have had, in such a degree as he, the gift of reducing the abstract conceptions of pure science to the level of the popular apprehension without descending to the puerile and frivolous."

A Very Simple Polariscope. A very simple form of polariscope may be made by the use of the mineral known as *tourmaline* (a silicate of alumina with many other elements). It is very strongly doubly refractive, and certain varieties of it arrest the ordinary ray altogether. Thus, a plate of it, cut parallel to the optic axis of the crystal, acts as a polariser, while a second similar plate, placed at right angles to the first, acts as an analyser. Two such plates can be mounted so as to form the effective little polariscope, which is usually known as the *tourmaline tongs*. Any crystal that is to be examined is simply placed between

the two plates. Now, we must turn to the greatest question of light.

The Discoveries of Clerk-Maxwell. James Clerk-Maxwell (1831 to 1879), a Scotsman and the first professor of experimental physics at Cambridge, has been repeatedly referred to in this course. When he was only eighteen he made two valuable contributions to physics. Not very long afterwards he made his first contribution to electricity, which was afterwards to be the subject of his greatest work. His theory of electromagnetism, in its fully developed form, first appeared in his book, "Electricity and Magnetism," which appeared in 1873 and has been described as one of the most "splendid monuments ever raised by the genius of a single individual." Unquestionably, Clerk-Maxwell is one of the greatest physical theorists of the nineteenth century, and his premature death must have sadly delayed the progress of science. His name will live longest, perhaps, in virtue of his *electromagnetic theory of light*, to which some reference has already been made, when we pointed out that its author not only declared that light must exert a pressure upon surfaces opposed to it, but also dared to estimate the magnitude of that pressure—his assertion and his estimate having since been confirmed by actual observation. We may quote from Professor Tait the briefest possible statement of what Maxwell accomplished:

"Maxwell has shown how to reduce all electric and magnetic phenomena to stresses and motions of a material medium, and, as one preliminary, but excessively severe, test of the truth of his theory, has shown that (if the electromagnetic medium be that which is required for the explanation of the phenomena of light) the velocity of light *in vacuo* [in a vacuum] should be numerically the same as the ratio of the electromagnetic and electrostatic units. We do not as yet certainly know either of these quantities very exactly, but the means of the best determinations of each, separately, agree with one another more closely than do the various values of either. There seems to be no longer any possibility of doubt that Maxwell has taken the first grand step towards the discovery of the true nature of electrical phenomena. Had he done nothing but this, his fame would have been secured for all time. But, striking as it is, this forms only one small part of the contents of his truly marvellous work."

Electromagnetic Theory of Light. These words were written about a quarter of a century ago, and since then it has become possible to speak in very much bolder terms of the electromagnetic theory of light. We now know that electromagnetic disturbances are transmitted through the ether at the same speed as light, and in consequence of the work of Hertz, who approached the question from the experimental side, as Clerk-Maxwell had approached it from the theoretical side, we know that electromagnetic waves are capable of refraction and reflection and therein follow precisely the same laws as those followed by light. Curiously enough, Hertz also was fated to die at the very height of his powers. He died in 1894, at the age of 37, and his epoch-making work was done when he was about 30. Not only did he discover the propagation of electromagnetic waves through space, but he measured their length and velocity, demonstrated their capacity for polarisation, and the transverse character of their vibrations. In other words, he proved, to quote Helmholtz, that "light consists of electrical vibrations in an omnipresent ether which is at once an insulator and a magnetic medium."

Hertz and a New Conception of Light. Hertz was the favourite and most distinguished pupil of the illustrious Helmholtz. His work, together with that of Clerk-Maxwell, has established a new conception of light—which the nature of our own sensory organs makes it difficult for us to appreciate fully. We must try to think of light as a man would think of it who had acquainted himself with all that is known upon the subject, but had been born blind. Knowing light by means of many of its manifestations and properties, but not by means of its effect upon the retina, he would have just such a conception of it as we have of the Hertzian waves. In other words, we must assure ourselves once more, firstly, that what we call light has been proved, by every means of proof that can be asked for, to be merely a few notes picked out for our immediate consideration, in consequence of the chemical nature of our eyes, from a great gamut of vibration with which the universe is filled; and secondly, that these vibrations are capable of interpretation in terms of electricity and magnetism.

This is all very well; but let us see how it affects our *conception* of the wave theory. The best and simplest analogy to a wave of light is to be derived from a rope attached to a hook at one end and held in the hand at the other end. To such a rope waves can readily be imparted; they seem to run along it and return. But, in point of fact, if we were to investigate the motion of any particle in the rope, we should find that it was moving up and down—in other words, at right angles to the line of propagation of the wave. Such a wave, then, would quite strictly correspond to a ray of polarised light. A ray of unpolarised light might then be conceived as consisting of the similar and simultaneous motion of an infinite or indefinite number of ropes, all vibrating about the same axis, but all in different planes.

Light a Process, not a Substance. This leads us into difficulties, because it seems quite incompatible with our notion of the ether as a continuous solid. [See page 936.] But now we must ask ourselves whether the electromagnetic theory of light does not require that we should abandon our simple physical analogies derived from ropes and the like. Possibly in so doing we may rid ourselves of some contradictions. Our best plan will be to follow Maxwell himself in this matter.

In what he calls a brief summary of the evidence for the undulatory theory of light, Clerk-Maxwell first of all infers from the fact of interference that "light is not itself a substance. . . . We cannot suppose that two bodies, when put together, can annihilate each other; therefore light cannot be a substance. What we have proved is that one portion of light can be the exact opposite of another portion.

"Among physical quantities," Clerk-Maxwell proceeds, "we find some which are capable of having their signs reversed, and others which are not. Thus, a displacement in one direction is the exact opposite of an equal displacement in the opposite direction. Such quantities are the measures, not of substances, but always of processes taking place in a substance. We therefore conclude that light is not a substance, but a process going on in a substance, the process going on in the first portion of light being always the exact opposite of the process going on in the other at the same instant, so that when the two portions are combined no process goes on at all. . . . We have determined nothing as to the nature of the process. It may be a displacement, or a rotation, or an electrical disturbance—or, indeed, any physical quantity which is capable of assuming negative as well as positive values. Whatever be the nature of the process, if it is capable of being expressed by an equation of this form, the process going on at a fixed point is called a *vibration*. . . . When we contemplate the different parts of the medium as going through the same process in succession, we use the word *undulatory* to denote this character of the process, without in any way restricting its physical nature."

The Nature of a Wave. The reader must pay the utmost attention to the last phrase. It will prepare us for what we are about to see—namely, that our illustration of the rope is only an illustration. As long as our notion of a wave is derived from any of the waves we know, we shall have no choice but to think of a wave of light as a displacement—that is, as a movement of certain parts of the ether. This implies that the ether is discontinuous, and leaves us hopelessly muddled and without any prospect of ever forming a concept of the ether that will satisfy all our requirements.

The original view of the wave theory was that a wave of light consists of a movement of the medium. We must abandon this altogether. Furthermore, we must abandon entirely all our preconceptions as to the meaning of the word *wave*. To define the term somewhat loosely, we must think of a wave as no more than *a recurrent process*. We must cease altogether to think of a wave of light as constituted of something which is moving up and down or from side to side. We are very far from asserting that when we abandon this conception, as we must, we shall be able to replace it by what Descartes would have called a "clear and distinct idea" of a wave of light. But, at any rate, we shall have travelled a little nearer towards the truth.

Clerk-Maxwell points out that Faraday predicted, in a remarkable fashion, the discovery that one and the same medium is concerned in the propagation of light and in electromagnetic phenomena. Faraday, like Clerk-Maxwell himself later, was very much concerned to oppose and disprove the really inconceivable notion of "action at a distance." He found himself compelled to believe, after studying the magnetic force, and the general character of magnetic phenomena, external to the magnet, that the luminiferous ether is involved in the transmission of the magnetic force. "Such an action," he says, "may be a function of the ether, for it is not unlikely that, if there be an ether, it should have other uses than simply the conveyance of radiation." This prediction of Faraday's has been most wonderfully verified, as we shall see.

Faraday's Work. But we have had occasion to refer to few more remarkable men than Faraday, and a brief discussion of his life must be included here. He was born, the son of a blacksmith, in 1791, and died in 1867. When he was twenty-one years of age he went to hear Sir Humphry Davy lecture at the Royal Institution, and the result of sending his notes of these lectures to Davy was that he was appointed laboratory assistant there. He remained and worked in the Royal Institution during the remaining fifty-four years of his life. His first work was mainly chemical and extremely interesting; most notably, however, perhaps, because a new kind of glass, which he then discovered, later enabled him, when he placed it in a magnetic field, to discover the rotation of the plane of polarised light under these conditions. Later, Faraday worked at electromagnetism with the greatest success, and in 1831 he made what Clerk-Maxwell calls the "crowning discovery" of the induction of electric currents.

Magnetism and Polarised Light. Fourteen years later he discovered the effect of magnetism on polarised light. We may quote part of his note on this discovery, especially because the last part of it has been so amazingly verified:

"Heavy glass was experimented with. It gave no effects when the same magnetic poles or the contrary poles were on opposite sides (as regards the course of the polarised ray), nor when the same poles were on the same side, either with the constant or intermitting current. But when contrary magnetic poles were on the same side there was an effect produced on the polarised ray, and thus magnetic force and light were proved to have relations to each other. This fact will most likely prove exceedingly fertile and of great value in the investigation of the conditions of natural force."

Faraday excelled in the presentation of science to people without scientific training, and notably to children. His scientific work shows him to have been possessed, in the highest degree, of the scientific spirit which seeks to follow truth wherever she leads. He was an earnest member of the small Christian sect who are known as Sandemanians.

Continued

DRAFTING INFANTS' CLOTHES

Drafting and Cutting out Baby Bodice, Day and Night Gowns, Princess Day Gown, etc. The Short-coating Set and Pelisse

CHILDREN'S CLOTHING
continued from page 3746

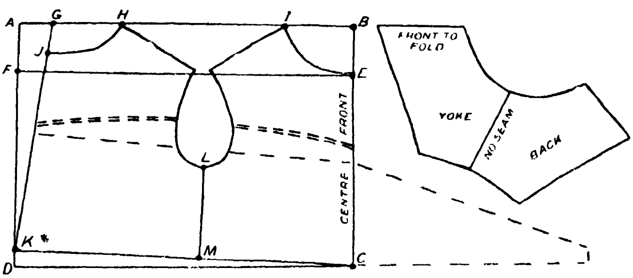
By AZÉLINE LEWIS

WE have now to deal with the drafting for the various garments illustrated in the last article. For the first as well as the second, or short-coating set, the following may be taken as good average measurements:

Chest, 20 in. to 22 in.; neck, 10 in. to 10½ in.; wristbands, 6 in. to 7½ in.

The long clothes should not exceed 30 in. in length, and may with advantage be shorter. No turnings are allowed on the following draftings; 1 in. should therefore be added for hems, ¼ in. to ½ in. for each tuck, if required for ornament, and ⅜ in. at seams and elsewhere. Very much fulness is not advisable for an infant's garment, unless the material be very thin and light.

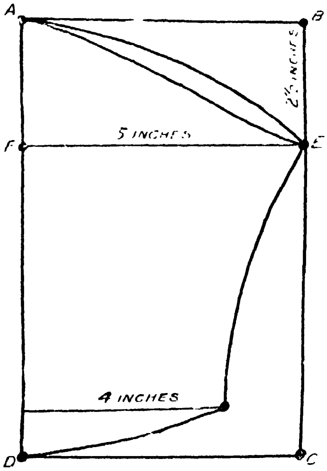
An Infant's Bodice. No. **8** gives the drafting of an infant's bodice, which will suffice for that of the long flannel petticoat, robe, and yoke of the day and night gowns [see diagram 1, page 3745]. The single row of broken lines indicates the direction to be followed for the strap bodice of the first long flannel, while the double row shows the method of obtaining the yoke, half of which is shown in the same diagram. [See DRESSMAKING for Blouse Cutting.]



8. DRAFTING INFANT'S BODICE

A to B and C to D are 10½ in.; A to D and B to C, 8 in.; B to E and A to F, 1½ in.; B to I, 2½ in.; A to G, 1 in.; G to H, 2¼ in.; G to J, 1 in.; J to K, a little longer than front; L to M, 3 in. Shoulders, 2½ in. These should extend to just above the line F E. If required fuller, simply add on an inch or so to centre front and back. Remember, too, that a healthy baby grows at an extraordinary rate, so that the garments should allow for expansion. The armholes should be quite loose, and *not less* than 9 in. round.

THE SLEEVE. A to B, and C to D, 5 in.; B to C, and A to D, 10 in.; B to E, 3 in. The under part should only be very slightly sloped out, and, indeed, for an infant, this is scarcely necessary [9].

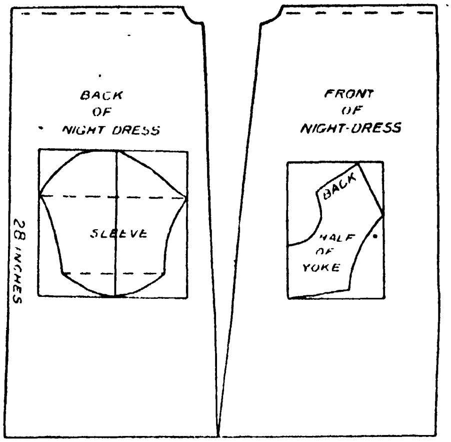


9. BODICE SLEEVE

With the aid of these two patterns, nearly all these little garments can be obtained, the skirt portion in each case consisting of straight, or very moderately sloped, widths from 27 in. to 32 in. in length, the former being quite long enough. For the long flannels, 1½ yd. of flannel, 36 in. wide, should suffice for one garment. This can be taken lengthways, and the 6 in. strip torn off at one side, allowing for the bodice, which should be double flannel. If only 27 in. wide, then 1¾ yd. will be required, two widths being necessary for the skirt, each 27 in. long, the remaining ¼ yd. being for the bodice. The edges may be either hemmed or festooned.

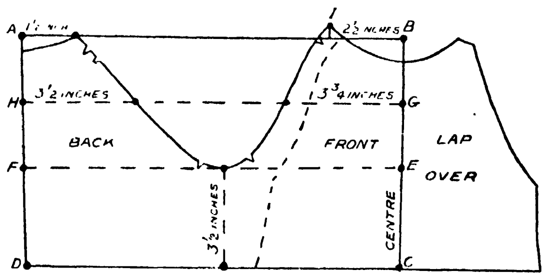
Day and Night Gowns. For the yoke day and night gowns, the front and back skirt widths are shaped as in diagram **10**, and sloped out a little for the under part of armhole. For the nightgown, 2 yd. should be enough, of which one width, and a half torn lengthways, are required for the skirt, the remaining half-width sufficing for the yoke (which is double), sleeves, and band. The daygown will require 2¼ yd. to 2½ yd., as this must be fuller and longer, to allow for hem, tucks, and ornamentation. Wide, embroidered, tucked and inserted flouncing can, however, be bought by the yard, which is much used for robes and day gowns, saving much work. If this be employed, 1½ yd. to 2 yd are enough for the skirt portion.

The Empire robe is made either of silk or cambric, and is cut from the bodice and sleeve patterns shown in diagrams **8** and **9**, the material being tucked and inserted as required before cutting out. Yokes and bodices can, however, now be bought ready-made. The skirt consists of two or more straight widths, tucked and ornamented as desired—this being baby's smart gown.



10. DAY OR NIGHT GOWN

Slip Skirt and Head Flannel. The slip skirt is made in exactly the same way as the last, without the bodice, ether of cambric, lawn, or silk. It can be trimmed as elaborately as desired, and is secured by a band, whilst two soft ribbon straps pass over the shoulders from the back, to be fastened to the waist in front. This skirt may be made to slip on over the head, but a better way is to make it fasten either at the side with two or more soft satin bows, or to fold it well over at the back without any fastenings at all. The pattern in any case is the same, except that for the last a little more fulness must be allowed when cutting, to allow for folding over.

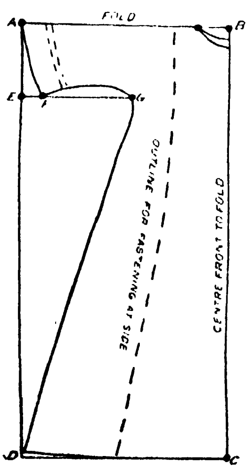


11. DRAFTING LONG FLANNEL

The head flannel has already been mentioned. The best way to make the casing for the ribbon at the head part is by means of the fancy stitches shown in diagram **5**.

The succeeding diagrams show how to cut out the hygienic set depicted in diagram **3**.

Bodice for Long Flannel. A to B, and C to D, 11½ in.; B to C, and A to D, 7½ in.; B to E, and A to F, 4 in.; G and H, midway between these last lines. I is ½ in. above line A B. The other measures are marked in the diagram, and the double front portion is cut as indicated by the broken line, the paper being folded back for the centre line marked B, C, E, and G.



13. NIGHTDRESS

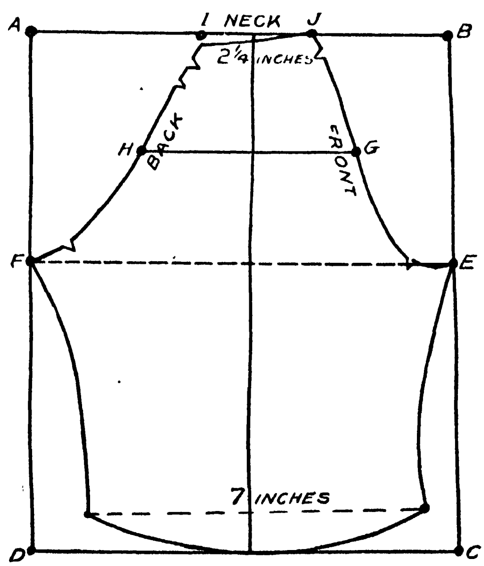
If required without sleeves, the back neck should fasten over the front and the armhole portion must be very neatly bound with soft ribbon [**11**].

THE SLEEVE. A and B, and C to D, 8½ in.; B to C, and A to D, 11 in.; B to E, and A to F, 5 in.; A to I, 3½ in.; and B to J, 3 in. G and H are midway between last points. The notches correspond with those of bodice and must not be forgotten [**12**].

The skirt portion is similar to those already mentioned. This pattern will do equally well for a nightdress, with the addition of lace edging and more ornamentation. It may also be made to fasten down the centre of front if preferred.

Nightdress. Diagram **13** is an extremely simple pattern for a nightdress; it is cut all in one piece, and fastens up at the centre-front, or at the side, as wished. A to B, 14 in.; B to C, and A to D, 28 in., or longer if wished. A to E, 5 in.; E to F, 1 in.; F to G, 6 in. The sleeve is curved slightly from F to G, but this is quite optional, as it can be made nearly straight. The neck is from 10 to 12 in. round.

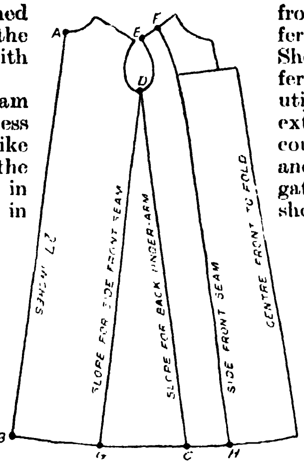
It can also be made double-breasted, as in the diagram; but in this case back and front must be cut separately, the extra portion following the shape of the broken lines. In this last shape the sleeves are better left



12. LONG FLANNEL SLEEVE

open at the top edge and fastened with narrow ribbons, while the edges should be finished off with festooning.

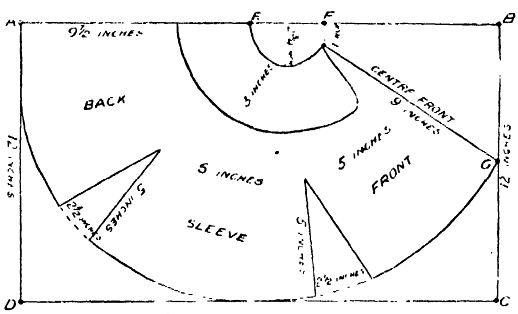
Princess Day Gown. Diagram **14** gives the drafting of the Princess day gown shown in **2**. This, like the former, fastens over at the side, and is put on exactly in the same way. The fastenings in this set should be alternately arranged for right and left. Thus, if the long flannel fastens to the left, the gown should fold over to the right, and vice versâ, a matter which is quite easy to arrange. This frock can be cut from the bodice-pattern [**8**] by sloping out the underarm seams for the necessary width. A, B, C and D represent the back, D, E, F, G and H the side-front, the remainder representing the fulness for front, the yoke of which is cut from the bodice as indicated. Both this and the full front are placed to a fold in the centre. The trimming of this robe is a matter of taste.



14. PRINCESS DAY GOWN

Diagram **15** shows how to cut the square kimono [**4***e*] which is too simple to need further explanation. The ribbons are to tie it round the arms. The neck is a circle about 4 in. in diameter. Diagram **16** illustrates the method of cutting out the circular kimono in **4***d*.

A to B, and C to D are 20 in. in length. A to E, 9½ in. ; E to F, 3 in. ; B to G, 6 in. The collar is cut from the neck portion three or more inches wide as desired, whilst the remaining measurements are given in diagram.



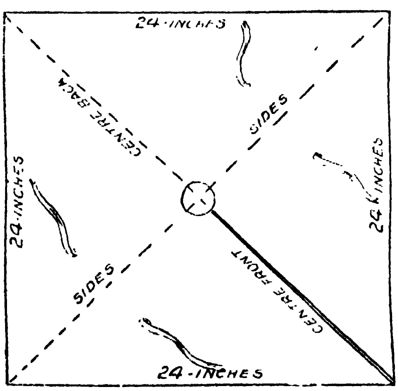
16. CIRCULAR KIMONO

In diagram **17** we have the little tea-jacket or outdoor coat shown in **4***b*, which is cut from the bodice of **11**, being preferable to the round armholes. Should the latter, however, be preferred, the bodice [**8**] can be utilised in the same way by allowing extra fulness at front and side. It could be also made with a yoke, and the lower part pleated or gathered on to it. The broken lines show the way in which the pattern of **11** is to be arranged. The sleeves for both have already been given [**9** and **12**], but in each case they should be much fuller, as this coat is designed to go on over the other garments. The length and trimming are also a matter of taste, about 8 in. being a fair average for the former.

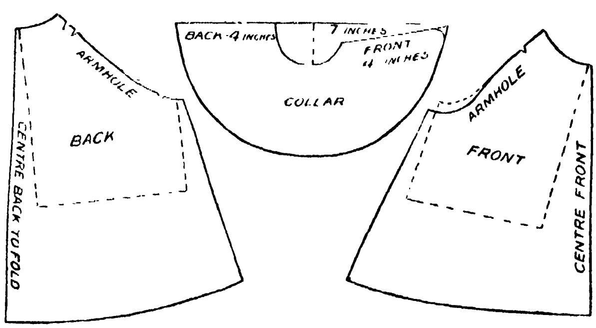
Diagram **18** shows the method of cutting out the cloak in **4**, which is cut on the same lines as the tea-jacket just mentioned, with the wide armholes and sleeves extending to the neck. This shape, however, can easily be formed into an ordinary sleeveless cloak by cutting it with a V at the neck part, as shown by the broken line between the armhole lines. Both capes are shown on the same diagram, but must, of course, be drafted separately.

A to B, and C to D are 41 in. ; B to C, and A to D, 38 in. ; B to E, and A to F, 20 in. The sleeve opening is 6 in. to 7 in. in depth. For the cape, G to H and I is 20 in., G to J and K, 3 in. Pivot from G to H and I for the outer circle of cape, then cut the neck as shown, and the upper one, or collar, from this. The method of cutting the sleeves is shown in **12**.

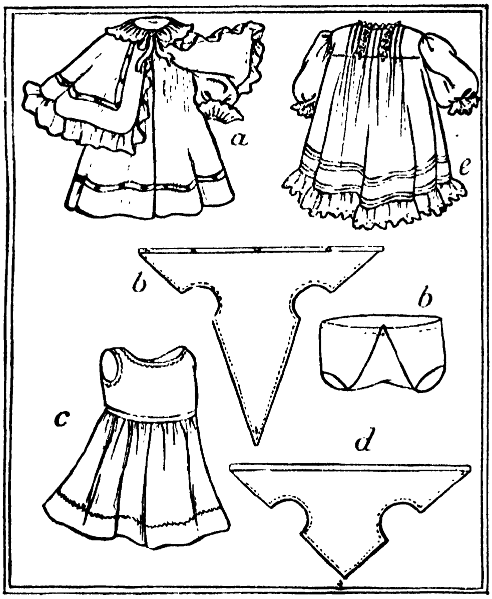
Note that this cloak can be made with a yoke if wished—a little rounded one for preference—which can be cut from **8**. In this case the lower portion is gathered on to the neck, and would not be cut up to it. For this cloak 3½ yd.



15. SQUARE KIMONO



17. TEA-JACKET



19. SHORT-COATING SET

of 44-in. goods are required. If less than 44 in. wide, divide as shown by the broken line, and allow nearly double the quantity of material.

Short-coating Set. The operation of short-coating is now never deferred beyond three months, and may take place before this period, whilst some babies, whose mothers are progressive, have never worn long clothes at all, and have never suffered from the omission.

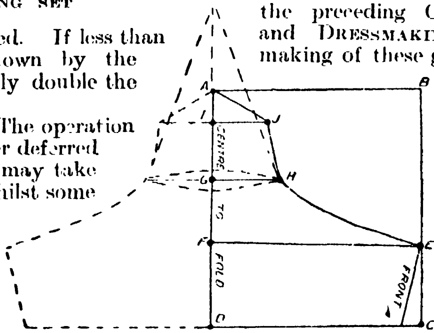
The garments themselves differ very little in shape from the long ones except in length and size; the bodices in nearly all cases being larger, which, however, is quite an easy matter to arrange and needs no explanation [19].

Some additions are necessary, however, and these include the pilch, or first drawers, and several dainty pinafores; *b* and *d* show two shapes of pilch; *c* the small petticoat, *a* the pelisse, and *e* the frock.

When the laundry bill is a matter of no concern, pinafores are often never used at all for the first few months, the child always being dressed in fresh, white frocks.

Diagram 20 shows the first drawers, which in the new baby's wardrobe would be of flannel, but in others of cambric or fine longcloth, in each case with the leg-openings bound and trimmed with lace.

To draft the pattern, make A to B, and C to D, 13 in.; B to C, and A to D, 16 in.; C to E, and D to F, 5 in.; F to G, and G to I, 3 in.; G to H, a little more. The broken line on either side of G and H shows the portion to be hollowed out between the legs to give a little more shape here for the next size; but for the very first stage this is not necessary. Half a yard of 36-in. flannel is required. Some people prefer the pilch made with the points extending up to, and fastening to, the waistband. This, however, is a matter of taste, and it is quite easily managed from the same pattern, as shown by the broken lines in the diagram.



20. FIRST KNICKERS

A pair of stork pants should also be added to the list. These are much the same as those shown in the diagram, but are made of thin waterproof material.

The Pelisse. The pelisse can be cut from any of the form r patterns, and should extend from 1 in. to 3 in. below the feet.

At the crawling stage a pair of loose drawers, or a crawling suit, will be found very useful for keeping the petticoats clean and doing away with frequent changes. The latter is cut somewhat similar to the combination illustrated in the next article, but somewhat fuller in the legs; whilst for the former the drawers portion of the small child's divided garment may be taken as a model, the knee part being gathered into a band instead of left loose, as shown in the sketch.

It is inferred that the reader has followed the preceding Courses on UNDERCLOTHING and DRESSMAKING. Any details in the making of these garments apparently omitted from these lessons will be found to have been previously described. Speaking generally, when once the rudiments of plain needlework and the drafting system have been mastered, it is merely a question of adapting the patterns to the garments required.

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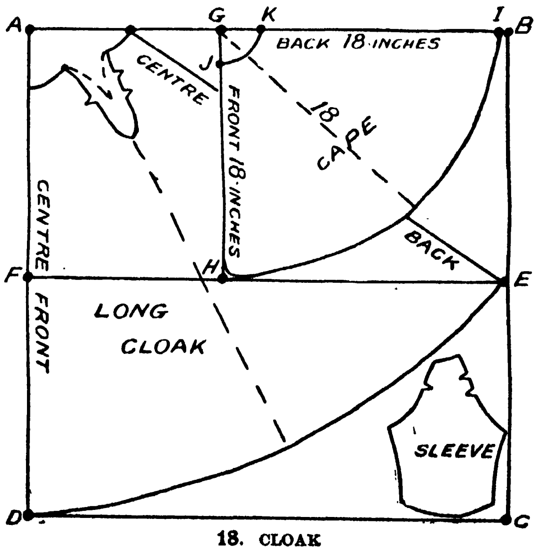


18. CLOAK

THE ORGAN

Construction of the Instrument. Pedals, Keyboards, and Stops. Touch. Fingering. Expression. Church Music. Recitals

By J. CUTHBERT HADDEN

THE organ is known familiarly as the King of Instruments. It deserves the name alike as regards its compass, its powerful dimensions, and the space which it occupies.

Nature of the Instrument. In inception, at least, it is one of the very oldest of musical instruments. Such, too, is the flute, and, as Sir John Stainer has conclusively shown, the history of the organ is nothing more than a narrative of the efforts made by man to bring under the control of one performer a large number of flutes. Not flutes of the modern orchestral type, blown at a hole in the side, but flutes with a mouthpiece, very much like the familiar penny whistle. There is little difference between a penny whistle and an organ pipe, and if you think of the primitive organ as an instrument in which several penny whistles were brought under the control of one performer, you will have a good idea, to start with, of the evolution of the "King of Instruments."

First, they stuck several flutes over a wind-chest supplied by bellows; then, gradually, they added more and more flutes in the form of real organ pipes. A keyboard naturally followed. Before its invention, the pipes (say, the flutes) were "made to speak or be silent at the will of the player by pulling backwards or forwards pieces of wood, the ends of which either closed up the foot of a pipe or allowed the wind to enter it." This was a slow, clumsy business. The first keyboard (about the end of the eleventh century) was not quite so slow, but it was nearly as clumsy. The keys were so long that five of them took up about the space of eight on the modern keyboard, and the player had to hit them with his closed fist or press them down with his elbow, so that he was called not the organist, but the "organ beater." Organists of those days required the muscles of a blacksmith.

Construction. In time the keys were improved until they became practically what they are to-day, except that where the keys are now white they were black, and where they are black they were white. Keys for the hands were subsequently (fifteenth century) followed by keys for the feet, which, in the modern *pedal board*, as it is called, are one of the essential characteristics of the pipe organ. Reed pipes (to be explained later) came also in the fifteenth century, and inventions and improvements went on with the progress of time until now, in the organ of to-day, we have one of the grandest and most complete of all musical instruments—the veritable "King."

To explain the construction of this "instrument of instruments" with any minuteness would occupy a vast amount of space. The student should try to see an organ in actual process of "building." No amount of printed matter can compete with such a lesson as that, and indeed, the modern organ is so complicated a piece of mechanism that it is very difficult to make its details clear on paper. Broadly speaking, these details go into the following divisions: (1) The apparatus for collecting the wind—that is to say, the bellows; (2) the means for distributing the wind—the wind trunk, the wind chest, and the soundboard grooves; (3) the mechanism for playing the instrument—*viz.*, the keyboard and the key movement; and (4) the mechanism for controlling the use of the tiers of pipes—*viz.*, the draw-stop action.

The Mechanism. The bellows requires no explanation. Its primary function is to collect the wind and to send it forward by means of the wind-trunk to the wind-chest, where the wind is directly drawn upon as required. This wind-chest runs the whole length of the sound-board, upon which the various tiers of pipes are stacked; and in it are located the little contrivances called *pallets*, which prevent the wind getting further until they (the pallets) are operated upon from the keyboard. This brings us to the key-action. The pallets are, of course, a long way beyond the player's reach, but they are moved instantly by rods connected with the tail of the key. The action is simple enough in its operation, though it involves the use of three or four separate pieces of mechanism—the *sticker*, the *roller and tracker*, and the *pull-down*, to use the technical terms. By the draw-stop action the player is enabled to bring into use or shut off any particular set of pipes. If it were not for this action, all these sets of pipes would always sound together, just as they do when the organist pulls out every "knob" in his organ. Every separate set of pipes has beneath it what is termed a *slider*. This slider is perforated with holes corresponding with the mouths of the pipes. When the slide is "open" the holes are exactly beneath the mouths of the pipes; when it is shut (by the draw-stop), the wind is cut off, and the pipes are necessarily silent. In short, to quote a musical dictionary maker, "the pulling out of the draw-stop rods in front of the organ so far admits the wind to the pipes that it is only necessary to press down a key, which opens a small valve, to make the pipe connected with it speak; the pushing-back of the register-rod

(the whole sweep of the movement is only about an inch) silences the stops." Here, in brief, is the mechanism of the modern organ. But, after all, one feels the explanation to be so sadly futile that he comes back to the originally-suggested advice: see an organ in actual process of construction.

The Piano as a Substitute. Now, there are peculiar difficulties about the study of the organ. You may buy a clarionet or a flute and carry it home in your pocket. A violin easily goes into a portable case. A piano is a recognised piece of household furniture. But you cannot carry about an organ; it cannot readily be set up in an ordinary sized room. You find it in the church only, and you have to make a variety of arrangements before you can enjoy your practice —take lessons from the organist, engage a blower, perhaps bargain with the churchwardens or managers, and so on. Hence it has to be admitted that it is hardly possible to study the organ without calling in the aid of the instructing, living organist. It is only through him, as a rule, that you can get at an organ, though, in London, at least, the student can always command the use of a practice instrument at a moderate fee. Nevertheless, if one is once fairly grounded in the elements of organ-playing he may continue his study unaided as easily as the violinist or the pianist. He may, perhaps, obtain a church appointment where the modest salary is in keeping with his modest abilities. Thus he will have an organ at his sole command, by which he can readily advance to the heights which the great men of the organ world have won and kept.

Then, as already hinted, you may hire an instrument by special agreement. If you do not know of any such instrument, advertise for it. There are churches which hire out their organs to students as a means of reducing a debt that rests on the instrument. Finally, you may have a pedal attachment fixed to your piano. The "foot-keys," remember, are the essential characteristic of the pipe organ. The manual keyboard of the organ is the same as the keyboard of the piano; which means that you can "get up" all your organ music on the piano—except the part for the feet. For this latter you must add to your piano a set of pedal keys. It is a simple matter, though it will cost you a ten-pound note for a good and reliable piece of mechanism. But think what you gain! You can practise your organ studies whenever you like. You do not require to go to the church every time you want to "run through" a Bach fugue or a Mendelssohn sonata. You save the cost of a blower. And—you add to the certainty of your execution; for a mistake on the piano is much more easily detected than a mistake on the organ, and on the piano you must hit a pedal note "clean" or you will know it!

Necessary Preliminary Technique. Whenever possible, get at the organ itself; when that is not possible, the best available substitute is the piano with the pedal attachment. But it is, at best, a makeshift; a supplement, as it were, to work at the keyboard within the church walls. And here another point suggests itself. Keyboard study should never be begun with the organ. It is a waste of time. If you cannot play at all, do not dream of attacking the king of instruments until you can at least play a little. In the words of Sir John Stainer, an organist "should not commence his practice on the king of instruments until he has a thorough knowledge of musical notation, can read fairly at sight, is able to play all his scales evenly and rapidly on the pianoforte, and, above all things, can carry his hand in a good position while playing chords and scales." For giving elasticity of action to the fingers and wrists, for forming the position of the hand, and for training the touch, the piano stands unrivalled. As Stainer insists, all this portion of an organist's work (and it is a most important portion) should be done at the piano. The point must be emphasised. When you have to hire out an instrument, and perhaps to pay for a blower, it is out of the question that you should sit at the organ doing that which you had far better, and with no financial outlay, do at the piano. So, then, do not be in a hurry to get to the organ itself. Learn, first, to play a little on the keyboard—either the keyboard of the piano or the harmonium, the former by decided preference. Then, when you sit down to the organ, instead of having to play scales and finger exercises, and pieces of "absurd simplicity," you will be able to attack at once the peculiar difficulties of the instrument, which consist, essentially, in the combination of playing with hands *and feet*.

Difference in Organs. Having cleared the way of all preliminaries, let us suppose ourselves seated at the organ, ready to begin actual work. With the instrument thus before us, new points for explanation confront the instructor, for an organ is not like a piano. Roughly speaking, there is nothing to explain to the young pianist about his instrument but the keyboard and the loud and soft pedals. There are dozens of things to explain about an organ, to say nothing of the fact that no two organs are alike, as all pianos are essentially alike. For example, we may imagine ourselves seated at an organ with two or three or even four keyboards; with a dozen stops or five dozen stops; with a straight or a radiating, a flat or a concave pedal-board; with a "balanced" swell pedal, or an old-fashioned pedal fixed by a notch. The "action" of one instrument may be tracker, that of another pneumatic, of a third electric, and so on. There is, in fact, no end to the diversities of organs. For the student's purpose, however, it will be enough to take the essentials, and leave the differences for his own individual attention as they present themselves.

In the first instance, then, there are the *manual keyboards*. Organs of two manuals are by far the most common. In these the lower manual represents the *Great Organ*, the upper manual the *Swell*. The names are sufficiently informing. The Great Organ is so called because it includes (or ought to include)

all the nobler and more characteristic stops—those of large scale and powerful tone; while the Swell Organ owes its name to the fact that all its pipes are enclosed in a box with a sort of venetian blind front, which can be opened and closed by the foot of the player for the production of *crescendo* and *diminuendo* effects. When there is a third manual it represents the *Choir Organ*, so called because its usual delicate quality of tone was supposed to be specially suitable for the accompanying of voices. A fourth manual is found only in very large instruments, principally in cathedrals and concert halls. It represents the *Solo Organ*, the stops in this case being mostly of an orchestral character, and such as are used for solo purposes.

Pedal Keyboard. So much for the manual keyboards. Next we have the pedal keyboard, an essential feature of every pipe organ. It covers nearly two and a half octaves—from CCC to F, to be precise—and its function is, through its stops, to provide a suitable bass for the manual stops. There are various kinds of pedal-boards, unfortunately. The keys may be perfectly straight, or they may be disposed in radiating form. Either of these, again, may be flat or they may be concave—that is, gradually rise at the extremities. The student will readily adapt himself to whatever kind of pedal-board he has to practise on; but he ought to seek opportunities of playing on pedal-boards of a different pattern, otherwise, if he is being tested for an appointment on an organ whose pedal-board is unlike that to which he has been accustomed, he may easily come to grief. It is a pity that all pedal-boards are not alike, as all manual keyboards are alike; since the divergence exists, the student must make the best of it.

The Stops. Now for another essential feature of the organ—the stops. Here, again, there are diversities as regards the nomenclature, but these are to a large extent minimised by the never-failing uniform practice of indicating the pitch of the stop directly below its name. Thus one sees "Bourdon, 16 ft.," "Open Diapason 8 ft.," "Principal, 4 ft.," etc. This requires some explanation, though it is very simple. It means that the longest pipe of the particular stop is of the length (in feet) indicated on its stop handle. On the pedal the 16 ft. is the groundwork; on the manual the groundwork is the 8 ft., the stops so marked giving exactly the same pitch as that of the pianoforte. Stops marked 4 ft. are, of course, an octave higher; those marked 2 ft., a couple of octaves higher. Thus, to put it in a word, the student will understand that when he pulls a stop marked "8 ft." he is getting the standard pitch; when he pulls one marked "4 ft.," and plays with that alone, he will, in effect, transpose his music an octave higher. The resultant rule is that he must always use the 8-ft. stops as the foundation tone of the manuals; the 16-ft. stops as the foundation tone of the pedal. It is from these "foundations" that he must build up. If he wants to brighten the manual 8-ft. tone he will draw upon the 4-ft. and 2-ft. stops; if to brighten the pedal 16-ft. tone, the 8-ft., and so on.

The Two Classes of Stops. But then there is the question of the individual tone-quality of the various stops. That is best determined by actual experiment. Still, there are certain broad principles which are easily stated. Organ stops are of two main classes—flue stops, so-called, and reed stops. The flue stops include all the open pipes, such as are seen on the front of an organ, in which the tone is produced by a current of air entering the foot of the pipe; while the reed stops owe their tone and their name to the vibration of little metal tongues, as in the harmonium and American organ. The "reeds" are all enclosed in metal tubes; the "flues" may be either of metal or of wood. It would occupy far too much space to give a list, with accompanying tone descriptions, of the multitude of stops found in large organs. Nor is such a description at all necessary in a work of the present kind. What the student has to note at the outset is that he must start with the 8-ft. tone on the manuals and the 16-ft. tone on the pedals. These are his bread and butter of the instrument, to to speak. As he advances, he will want to make experiments for himself—to contrast this stop with that other stop; to balance one stop on the Great with another on the Swell or Choir; to try this or that stop as an accompaniment to the "oboe" or the "clarinet;" to test the "open diapason" on the Great or the "horn" on the Swell as a solo in the tenor octave; to see what can be made of the wood stops and the reeds in combination; and to make a hundred other experiments. This is one of the delights of organ study. The stop combinations and "effects" are endless, and once the young player has surmounted his first technical difficulties he should make constant tone-colour appeals to his ear with every instrument within his reach. Mere book knowledge of organ stops is as useless to the player as a book knowledge of angling is to the man who would catch trout.

Manipulation of the Stops. Well, the stops are there—on the right and left of the keyboard. As a rule, when you want them individually, you must pull them by hand. But it is not always either necessary or possible to pull them by hand, and so certain mechanical contrivances are made for getting them out by the foot. If you look below the lowest manual keyboard, just over the pedals, you will see a set of little irons, technically known as "composition pedals." By means of these you can force out a particular combination of the manual stops (sometimes the pedal is included), the arrangement, as a rule, following in *crescendo* order, from *p* to *ff*. These composition pedals are indispensable for sudden changes in power of tone, and the student should early familiarise himself with their use. But let him always remember that he must never sacrifice the time or rhythm of a passage in an effort to change his stops. "Stops," says an eminent authority, "should on no account be changed, either by composition pedals, pistons, or the hand unless it can be done without breaking

the time or disturbing the rhythmical form of the music."

Swell Pedal. As regards the swell pedal, not much need be said at this stage. The management of a *crescendo* and *diminuendo* which the swell pedal puts at the disposal of the player is not a matter for elementary experiment. For one thing, it robs the pedal-board of a foot which the young player can ill spare. He may get a little more expression, indeed, by his use of the swell pedal; but, on the other hand, it is more than likely that he will bungle the performance of a pedal passage. Stainer's rules for the use of the swell *crescendo* and *diminuendo* ought to be impressed on all young players. They are as follow:

"Never use the swell pedal unless the proper expression of the music demands a *crescendo* or *diminuendo.*

"Never sacrifice the proper performance of a pedal passage for the sake of using the swell pedal.

"Be as careful of the way you let the pedal return upwards as of the way you press it down.

"Observe carefully the length of the passage marked *crescendo*, and do not get the swell fully open till the *climax*—unless you are prepared to carry on the *crescendo* by adding stops.

"The swell *crescendo* is the more effective if not used too frequently."

This should be the student's gospel as regards the use of the swell pedal. The bad player never has a leg to spare but he uses it in pumping the swell pedal up and down, often with the most ludicrous and distressing effects.

Position of Player. A word upon another matter. See that you are comfortably seated at the instrument. Occasionally the pedals are fixed too low down for the heels to reach the naturals with ease; sometimes they are set so high that the player's knees knock against the underside of the board on which the manuals rest. There is no remedy for these errors of the organ builder. But very often you will find, when there is any discomfort, that a little adjustment of the height of the organ-stool will put things right. Obviously, a six-foot organist does not want a seat so near the pedal board as a Zaccheus of the keyboard. Stainer's is really the best test of a good position, and it is this:

When seated, lift up both feet and hold them just over the pedals so that they could play, if required, either on the long or short pedal-keys, *at the same time* holding both hands over the manuals, so that they could play, if required, on any of the manuals either separately or in conjunction with the feet.

If the pupil, while in this position, has an uncomfortable sensation that he is likely to knock his nose against the desk, the organ-stool is too far away from the keys or he is sitting too near its edge.

If the pupil cannot move his knees freely to the right and left, the stool is either too near the keys or he is sitting too far on it.

Much has been written about the right sort of footgear for the organist. The matter is entirely one for common-sense. The player's ankles should be quite free; therefore, he should not wear boots. A well-made shoe, not too heavy nor too slim, with solid, broad heel-pieces, and neither too narrow nor too round at the toe, is what experience has pointed out as most suitable. Very thin soles mean an unnecessary strain on the muscles of the foot, and narrow heels (such as ladies wear) can never be quite sure of the key. There are organists who could pedal in Wellington boots, but for the average player there is nothing to beat the shoe as just described.

Practice. Now it seems time to begin actual work. In the way of practice material, it would, we think, be unwise to attempt to give the student anything better or more helpful than the excellent exercises written by men whose names are familiar in every household. Nine-tenths of the organ students of these days begin with Stainer's "Organ Primer" (Novello), and thereafter, if not conjointly, work through the greater part of Rinck's "Practical Organ School," as edited by W. T. Best (Novello). Nothing could be better for the purpose. The Stainer primer begins with a large variety of simple exercises for the feet, following these by exercises for acquiring the characteristic manual touch of the organ; and going on, through graded stages, to the playing of hymn tunes and pieces, and the more elaborate fugues and other work peculiarly associated with the king of instruments. Every student of the organ should found his practice on this excellent manual, supplementing it, perhaps (if he desires to excel in pedal work), by Mr. G. E. Lake's "Pedal Scale Studies," issued by way of supplement to the primer, by the same publishers.

Rinck's "Organ School" is hardly less valuable. Most of our cathedral and other notable organists have been reared on it, and its contents have the recommendation of being at once good technical studies and good music—always useful to the organist in active church work. The "School" is divided into six parts. It will depend on the student's already-acquired facility at the keyboard whether he should work through the preliminary thirty-six exercises in two, three, or four parts, without pedal. These exercises are doubtless useful, but they are not characteristic, and might as well be played on the harmonium or the American organ. We would suggest rather that, assuming a certain technical familiarity with pedal and manual keyboards, a start should be made with the twenty-four preludes in the twelve major and twelve minor keys, following them up with those in the six less usual keys of C♯, G♭, C♭ major, and G♯, D♯, and A♯ minor (Nos. 37 to 66). "In support of my recommendation of such exercises," says Rinck himself, "it may be enough to quote the opinion of my ever dear master, the late Mr. Kittel, organist at Erfurt (the latest living pupil of John Sebastian Bach), who strongly advised practice in all the keys. The same course of study is also enforced by the father of all organ players, the great John Sebastian Bach himself, who, in his 'Forty-Eight Preludes and Fugues,' has given two preludes and two fugues in each and every

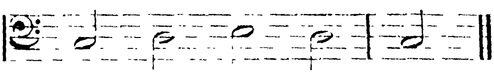
of the twelve major and minor keys. An organ player should obtain such facility in mastering every key as to overcome every difficulty, however presented." These are valuable words, and the student should weigh them well. When he has conscientiously worked through Rinck's "Thirty Preludes in all the Major and Minor Keys," he will be fit to attack almost anything in the way of ordinary organ music. But first he must go a certain length through the Stainer primer, as is more clearly indicated later.

Playing with the Feet. The prime difficulty with the organ student is that of learning to play with the feet. If he already plays the piano or the harmonium, the manual keyboards of the organ will be perfectly familiar to him. But it is otherwise with the organ pedal-board—the only thing of the kind. That is one of the essential features of the instrument; a feature requiring special study, and better attacked at once before attempting the combination of hands and feet. Turn, therefore, to the Stainer primer, and look at page 37. Stainer's plan with the beginner—and it is a very good plan—is to make him find different notes on the pedals by *feeling with his toes.* This is done by discovering the gaps between the short keys, corresponding to the open spaces at the back of the white keys of a piano between B♭ and C♯, and E♭ and F♯. Just so a blind man learns to play the organ, and because he is debarred from looking at his feet, as most sighted students of the instrument are tempted to do, he acquires a confidence which proves his infirmity a positive advantage.

Stainer indicates the gaps between the short keys (in their order from the lower end) by the letters U, V, W, X, Y, Z. If you thrust your foot into V, the flat of the foot will be over the extreme ends of the keys E and F; if into W, it will be over B and C; and so on. This is what you are to do by way of preliminary practice in "finding" the notes. Having acquired a measure of certainty in locating the keys in these spaces, you go on to find the notes lying near them. For example, you find W with the left foot; then, after feeling the sides of the short keys B♭ and C♯, you draw the foot out and strike B firmly and without hesitation. Stainer gives three whole pages (pp. 38, 39, and 40) of exercises in this finding of individual pedal keys by the "feeling" process. You must work through them, coupling the pedal to one of the manual keyboards, so that the eye may come to the assistance of the ear in determining whether you are perfectly right. Do not get into the habit of peeping down at your feet. That way lies perpetual nervousness as a pedallist.

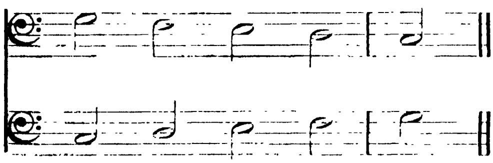
Position on the Organ Stool. These "feeling" exercises mastered, you proceed to the practice of exercises for alternate toes, which, as Stainer remarks, will serve the double purpose of rendering the ankle-joints elastic, and of accustoming you to the measurement of intervals on the pedal-board. The three pages of exercises (41, 42, 43) in this form are made to cover practically the entire range of the foot keys. The student will at first feel himself a little uncomfortable as he works down to the extreme lower notes or up to the higher notes of the pedal-board. He will be tempted to shift his position on the seat to "get nearer them," as students often say. But he must not do this. The legs alone must be made to meet the greater distance either way. You must keep conscious that you are going to the extreme ends, and be continually inclining—but only inclining—your knees and body in that direction. This gradual effort will accomplish it, so that no *sudden* movement in the required direction will then become necessary. You must be particular to observe that you are not assisted in this by the hands, whether by resting on the seat or keyboard frame, or by manual playing, for you must school yourself to accomplish this movement without such extraneous aid. But above all, you must not shift your position on the seat. To do so upsets that subtle process of half-mental, half-mechanical measurement of pedal-board intervals which the organist finds so essential. Fix your position on the seat, and keep to it, no matter what part of the pedal-board is being used.

Pedal Scales. Many organ teachers insist on their pupils practising a complete set of pedal scales at an early stage of their studies. For students who wish to follow that plan there are Lake's "Daily Studies and Complete Scales" (Novello) and Pearce's "Pedal Scales" (Hammond). At this stage, however, Stainer's plan of scale passages seems more practically serviceable. These passages [see pages 51 and 52] he marks for alternate toes, the use of the heel being held over for the present. The student should understand that the system of alternate "toeing" is always to be preferred whenever it can be adopted, as producing a "cleaner" and more certain performance. And he must further note that in this system the right foot has always to be kept well in front of the left, so that the one may pass behind or the other pass in front, as the case may be. Thus, supposing you have this little passage to play:



you will place the left toe well back on the C, the right toe well forward on the D; the left will come up behind the right (the heel of which is raised a little to let it pass comfortably), and strike the E; and so back again to the C. Students often get into the habit of huddling the feet together near the short keys, which always produces a clumsy and uncomfortable performance. In working through the Stainer scale passages, then, let the pupil aim especially at the acquirement of facility in pedalling thus with alternate toes. One must candidly admit that it is somewhat monotonous playing on the pedal-board alone, but the drudgery is inevitable, and must be faced by all serious students of the king of instruments. It is sheer waste of time for the mere beginner to attempt the union of hands and feet while he is still unable to use the feet alone.

Manual and Pedal Keys. Having gained a certain facility in the use of the foot keys, the next thing is to attempt a combination of manual and pedal keys. This sounds much easier than it usually proves to be. It is a curious fact, which you may readily demonstrate for yourself, that the feet generally want to go the same way as the hands—as the left hand especially. An old master was fond of illustrating this to his pupils by making them write the capital D, with its turn to the left, while the foot was *at the same time* tracing a half-circle in the opposite direction—towards the right. The student may make test of the letter performance, or he may try playing this—the upper part with the left hand on the manual, the lower part on the pedals:

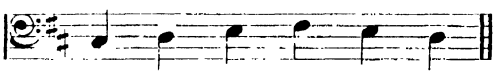


If he does not feel that he would like to have the feet going in the downward direction of the fingers, he may consider himself lucky. In any case, he must aim at complete independence between hands and feet, for which special purpose he will study, as a beginning, the five exercises printed by Stainer on pages 56, 57, and 58. They are called "easy," but the student must not feel discouraged if he finds that they do not answer to this description in his case. To play from three staves, the right hand on one manual, the left hand on another, and the pedal in addition, is by no means "easy" to the beginner at the organ. The best and shortest way of getting over the difficulty is to make sure of the manual parts first; then take the pedal part, first with the right foot alone, and next with the left foot alone. Finally, take all three together. With regard to the manuals, see that you have the tone-quality sufficiently contrasted to make each part stand out distinctly. Thus, if you take the right-hand part on a flute stop in the Great, you might take the left on a reed in the Swell. It is preferable in these exercises to couple the pedal to the Great keyboard.

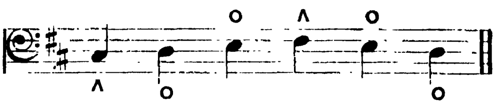
Touch. At this point it may be well to say something about the manual touch of an organ. This differs from the touch of a piano in several respects. First, as Stainer puts it, an organ key is pressed down, not exactly struck, as on the piano. Next, the loudness or softness of the tone is quite unaffected by the force used by the finger. In some organs (those of older make chiefly) the touch is abnormally "heavy"; in others, it is abnormally light—so light that the weight of a feather will almost make the key sound. Again, there are instruments in which the touch of one manual is different from that of the other manual or manuals. In view of this fact, there is a recognised rule that the player should adjust his touch to the heaviest manual. If he doesn't do this, he is in some risk (when changing from the lighter to the heavier manual) of passing over one or more keys without producing any sound. On the whole, however, the touch of the modern organ is a light touch; and in that respect Stainer's remarks on page 44 are coming to have less and less application in actual practice.

Having mastered the "easy" exercises for producing independence of hands and feet, we are now ready to look at the method of "toeing and heeling" the pedal-board. This method has to be called into use on two accounts. First, the free introduction of the short keys makes it necessary; and, second, there is the frequent withdrawal of the right foot for the manipulation of the swell pedal, making such a use of the heel absolutely imperative. Of course, in many cases it is a question whether toe and heel shall be used, or only alternate toes. Thus, Stainer marks as follows (it is understood that marks *above* the stave mean the right foot and marks *below* the left):

But there is no reason why this should not be played by alternate toes, beginning with the left foot. The one method is indeed more comfortable than the other. Take, however, the following:



Though it is quite possible to play this with alternate toes, it is much more easily played with a combination of toe and heel:



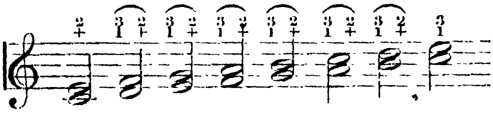
When both feet are free, it is therefore a case of choosing that form of pedalling, as to toe and heel, which is most comfortable and best calculated to produce a smooth and certain performance.

Experience will teach the player many tricks of pedalling—will show him, indeed, many instances in which a passage may be most easily played by ignoring all the rules. For the present he will do well to "stick to Stainer." The toeing and heeling exercises printed on pages 59 and 60 are sufficiently comprehensive, and when the student has completely mastered them he will have laid the foundation of the best possible methods of pedalling. They should be followed up by the five valuable exercises for giving still further independence of movement to hands and feet. These are in two parts only, the left hand being almost solely concerned with the manual part. The series of easy trios numbered 91, 92, and 93 embody the work done up to this point, and will be found an admirable test of the student's progress. These latter may, with eminent advantage, be followed by a careful study of Albrechtsberger's "Twelve Trios," edited by Arthur W. Marchant, and published in Novello's series of Musical Primers. Stainer

himself approved of these trios being issued as a supplement to his "Organ Primer."

Fingering. Up to this point nothing has been required to be said about any special method of fingering for the organ. Each hand has had only a single part to deal with, and the fingering has therefore been (as it will be in all such cases) essentially the fingering of the piano. But there is very little organ playing of this kind. It is rarely that the organist has not two parts in each hand, and while the pianist may turn his thumb under the fingers and the fingers over the thumb, the organist has to adopt quite another method. This is known as the *legato* style, and is obtained by changing the fingers on the keys without repeating the sound. The subject is dealt with pretty fully in the HARMONIUM AND AMERICAN ORGAN lessons, and to its treatment there the organ student may be referred.

The pianist studying the organ will find it somewhat difficult to acquire the legato style, and will, indeed, often be tempted to ignore altogether this, its most essential characteristic. The disjointed effect produced by fingering the organ by any other method is, however, so intolerable to the ear that no person of real musical taste will ever entirely shirk the very necessary practice of finger substitution. On the piano you may "run up" a scale in thirds without any changing of fingers and yet not outrage the ear; but such a scale can be satisfactorily played on the organ only in some such way as this:



For acquiring this legato style, the peculiar beauty of the organ, there is nothing better than the Stainer Exercises Nos. 94 to 108. No pains should be spared to get them done in the most finished manner possible. It is difficult at first, no doubt, all this finger changing; but the student will find that by-and-by the fingers will shift for themselves without waiting for the direction of the player's will—in other words, they will shift by instinct. It should be added, perhaps, that it is occasionally necessary, in the interests of a very smooth performance, to substitute one foot for another on a pedal key. This is eaily done when the key is a long one; happily, it rarely needs to be done on a short key, where it is naturally more difficult.

Expression. In all his elementary work at the organ the student will require to think more of "getting the notes right" than of the expression of the music. As he gains facility, however, he will want to acquire the command of such resources as his instrument affords in the matter of expression. These resources, unfortunately, are curiously limited. The organ is admittedly deficient in this respect—namely, that the player cannot influence the intensity of the tone by the character or force of his touch. Stainer mentions four sources of expression as being at the command of the organist: (1) The art of phrasing; (2) the contrast between legato and staccato; (3) the selection of the stops; and (4) the use of the swell pedal.

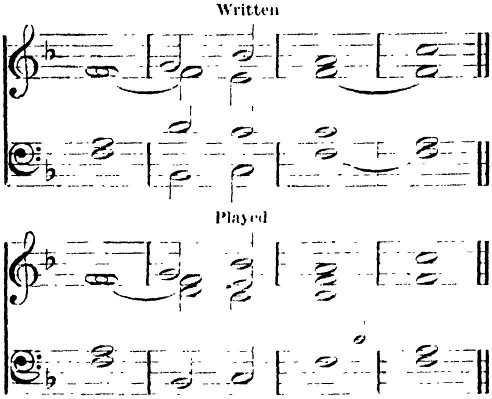
The first two belong, however, rather to advanced musicianship, while as to the third, it can hardly be said to come under the head of expression as generally understood. Practically, expression consists mainly in gradations of the tone intensity, and in that respect the organ player has to depend mainly on the swell pedal. The use of this indispensable piece of mechanism has already been referred to, at a stage at which, however, it would not have been advisable to advocate its employment. Assuming that there is a pedal part to play, it is clear that the young organist cannot effectively control the swell pedal unless he is able to manipulate the pedal-board with the left foot alone. The swell crescendo and diminuendo should therefore be held in abeyance until the student has acquired that expertness in toeing and heeling which the use of one foot implies. Of course, where there is no pedal part, this restriction does not apply.

Church Music. In taking up the study of the organ, most persons have in view the securing of a church appointment, either as amateur or professional. As the basis of an organist's church work is the playing of psalm and hymn tunes and chants, it will be well that the pupil should now address himself to this important branch of study. Simple as it appears, it could not be taken up at an earlier stage—first, because of the pupil's practical unfamiliarity with the pedal-board; and, second, because the legato style of fingering, which is alone used in this sort of work, had not been acquired. Assuming a fair command of the instrument in these respects, the troubles that will present themselves now will be those of "reading" and playing from four parts, and of adapting the system of finger substitution to the rendering of two parts by each separate hand.

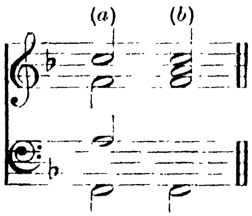
As regards the "reading," very little need be said here. It is chiefly a matter of practice, in which a knowledge of harmony and the general laws regulating part-writing prove of immense assistance. To the pianist or the unpractised organ student it is by no means easy at first for the eye to "take in" four parts at once. But one soon acquires this very necessary facility in reading when the mind is brought to help the eye; for chordal combinations and progressions as seen in hymn tunes are limited, after all, and familiarity comes with continued repetition. It is a good plan for the student to take some popular collection such as "Hymns Ancient and Modern," and work through it entirely as an exercise in reading. He need not waste time at the organ in doing this if he has a keyboard instrument—harmonium, American organ, or piano—in his own rooms.

There is one important point to be observed. Hymn tunes are written for voices—treble, alto, tenor, and bass. In playing them (without pedals) the organist takes the treble and alto with the right hand, the tenor and bass with the left. But the composer does not consider the

player's convenience in the "distribution" of his parts, and hence it often happens that a note or notes belonging to the tenor have to be taken by the right hand, and a note or notes belonging to the alto by the left. Stainer illustrates this in the following simple way:



Now and again it happens also that a chord as writen for the voices cannot be played at all as it stands. Thus, as at (*a*):



In such a case the plan is to transpose the unreachable inner part note an octave higher, always provided it does not, when so transposed, become higher than the treble. Thus the unplayable (*a*) becomes the playable (*b*).

Legato. As regards the system of finger-releasing essential to the legato style, that will be found rather irksome at first when applied to the rendering of four-part harmony. But the difficulty must be got over, and persistent practice is the only "royal road." Let the student keep ever before him this one important rule, that while notes belonging to inner parts (tenor and alto) may be "jumped," every note in an outer part (treble and bass) must have a finger ready for it. Of course, when the pedals are used for playing the bass, the difficulties of finger-releasing are much minimised as regards the left hand, which then (ordinarily) has only the tenor part to play; but no student should be satisfied with himself unless he can play all four parts with the hands alone in the true legato style, which is the characteristic beauty of the organ. Stainer gives just three exercises toward this end (Exercises 110, 113, 116), but they are sufficient to show the student what is required of him as a preliminary to any satisfactory rendering of psalm and hymn tunes and chants. They should be practised assiduously until they can be played with as much ease as an automaton might play them.

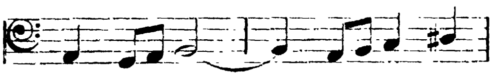
Hymn Tunes. But, of course, the organist does not always want to play his psalm or hymn tunes on the manuals alone. He wants to use the pedals, too; for if he didn't he might as well be playing a harmonium or an American organ. And this brings us to the various ways in which a hymn tune may be played on the organ, as illustrated by Stainer in Exercises 111, 112, 114, and 115. We may call the playing of the tune on the manuals alone the first way. The second way (Exercises 111 and 114) shows the treble and alto assigned, as usual, to the right hand, the tenor to the left, and the bass to the feet. In this manner, great care must be taken, as Stainer observes, to prevent the left hand from doubling the pedal part. It will usually want to do so, especially if the student has been accustomed to play hymn tunes on a manual keyboard alone. In actual church work the bass is often taken by the pedal an octave lower than written, and in that case the left hand takes it as it *is* written, along with the tenor part.

In the third manner (Exercises 112 and 115) we see the treble part played as a solo, with the alto and tenor assigned to the left hand and the bass to the pedals. This is the most difficult of all the three forms, the chief trouble being, alike as regards "reading" and execution, to get the alto and tenor together in one hand. As a matter of fact, the organist has here both to "arrange" his music and to play it. Very often he will find that the left hand is unable to cover the interval between the alto and tenor parts, in which case the two notes "must be inverted, or played in any position most convenient." This "soloing" out of a hymn tune, as it is called, not only gives a pleasing change from the more common methods, but it is useful, in the case of an unfamiliar tune, in so far as it puts the melody prominently before the congregation. In all such cases, it need hardly be said, a stop or stops must be used which will make the melody "stand out" much more clearly than the accompanying parts.

Stop Combinations for Hymns. Thus, you might "give out" a tune on the Swell "Oboe," accompanied by the Great or Choir "Dulciana" or "Stopped Diapason"; or you might use the Great "Open Diapason," accompanied by the Swell "Oboe" and one of the Diapasons. There are, in fact, endless ways of "giving out" a tune as regards stop combinations. These are for the player himself to discover. Meanwhile, as a student, he will find that it is quite enough to get the notes right in the particular ways indicated by his tutor. He will, of course, work through all the Stainer Exercises (110 to 116) meant to give him command over the various styles of chorale and hymn-tune playing. When he has finished these (which are specially arranged for him), he should attack his ordinary hymnal again, and, selecting, say, a dozen well-known tunes from it, proceed to play them in the various ways which he has just been studying. This is

the more advisable, as when actual church work comes to be done, it will be from the hymnal arranged for the voices, and not, as in the case of the tunes in Stainer, for the organ.

It is at this stage that Rinck's "Practical School for the Organ," which has been already referred to, might be taken up with advantage. Many organ teachers *begin* with Rinck, but Rinck assumes, much more than Stainer, that the student can already play on a keyboard instrument. The first section of his "School" includes, indeed, thirty-six "short and easy" exercises in two, three and four parts for the manuals, but these are not fingered and there is nothing to indicate the necessary legato style. The pedal exercises, again, are hardly such as a beginner can benefit by. But, having mastered his Stainer so far, the student would find it of real value to himself to work through the "Thirty Preludes in all the Major and Minor Keys" of Rinck's opening section. It is a pity, perhaps, that the pedal part is left without any indication of toeing and heeling. But the student, from what he has already learnt, can readily add these marks for himself, and thinking them out will do him a world of good. How to pedal this (from No. 37), for example, will lead to some interesting little experiments:



It can be done quite neatly in two or three different ways, and the question for the student will be which way he is to adopt. Hence, perhaps, it was better that Rinck did *not* mark his pedalling. Students who take up Rinck at the beginning generally have his exercises marked for them by a professor. Assuming Stainer beforehand, the student can easily "mark" for himself. At any rate, he should get through these thirty preludes. They are invaluable in many ways, and not least for their covering of all the less familiar keys. Students are apt to stop short at four flats and four sharps, but an organ-player should obtain such facility in all the possible keys as will enable him to overcome every difficulty, however presented.

After these Rinck preludes have been mastered a return might be made to Stainer, taking up the five short pieces (Nos. 120 to 124) intended to represent different styles of organ music and to give the pupil a wider sphere of practice before attacking the classical works of the great masters who have written specially for the instrument. But these should be studied concurrently with the third and fourth parts of Rinck, which embrace a series of thirty postludes, or concluding voluntaries, in the fugue style, all admirably calculated to add to the young organist's facility in the use of the manual and pedal keyboards. Rinck, indeed, though some regard his style as old-fashioned, ought to be the young student's daily bread, so to speak. Stainer's work is a primer, and cannot be expected to exhaust the subject.

A Reliable "School." As a royal road to thorough and "legitimate" organ-playing in all styles, there is no other "school" which will bear comparison with Rinck. A beginner who has been founded on Stainer can follow no better course than go through him slowly, allowing, say, three months for each book. "Rinck's name," wrote the late Sir Herbert Oakeley, Professor of Music in Edinburgh University, "will always live as that of a safe guide towards the formation of a sound and practical organ-player; his works comprise many artistic studies." Again, the illustrious French critic, F. J. Fétis, wrote: "In the composition of music for the organ the talent of Rinck was of a character peculiar to himself. His elegant and simple style was generally noble and dignified. His harmony has much about it that is uncommon and unexpected; his melody is sweet and touching. He did not try to write difficulties: his evident object was to work for provincial organists, to form their tastes, and to perfect their studies." This is no exaggeration, and the words are quoted by way of stimulus to the student who is seeking to acquire a real command of the instrument upon which Rinck himself was so distinguished an executant.

It is possible, of course, that some students who have gone through their Stainer will not care for the rather more severe, ecclesiastical style of Rinck. In that case they might continue their studies by means of Archer's "Organ Book" (Novello), one of the best and most comprehensive manuals of its kind. It continues exhaustively and thoroughly the admirable work which has been outlined in the Primer, so that a student who plods steadily through it feels, after he has done, that very little more can be pointed out to him in the way of instruction. Much of the work must, of necessity, be dry and technical, and, as such, may not interest the student. There are, however, many pieces, both short and long, in the work of considerable musical interest, though generally somewhat difficult. There are also Best's two volumes, first-rate both in design and execution; the one for manual work, the other containing an exhaustive set of pedal exercises and studies. On the whole, it will be best for the student who desires to supplement his Stainer to ask at a music-seller's for a sight of the works just named, and choose that which makes the strongest appeal to him. Students are of such different capacities and of such different tastes that it would be foolish to lay down any hard and fast rule in a matter of this kind.

Organ Compositions. But what about "pieces"? it may be asked. For even the most serious student desires occasional relief from exercises and studies, so-called. Well, notwithstanding all that has been written for the instrument, there is nothing better for accompanying the purely technical side of the young organist's training than a course of Henry Smart. Smart's organ compositions are published by Messrs. Novello, in twenty-two numbers. They embrace several styles, and run from easy to very difficult

music. The easy pieces can be attacked as soon as the player is familiar with the pedal-board, the fingering of the instrument, and the management of the stops. The same composer's "Organ Student" (Boosey) might also have attention. Smart's "easy" pieces, an authority has rightly said, are specially fitted as studies for students wanting to acquire the true "organ touch" on pedals and manuals. Indeed, a learner who knows his rudiments may find in this master's organ music a progressive school of the very best kind, provided only some judicious friend points out in what order the various pieces should be taken. A beginning should be made with No. 19 of the Novello set, after which might come Nos. 11 and 13; No. 18 is an easy march in G.

The Great Composers for the Organ. Along with these may be named the "Twenty-four Sketches" of Dr. E. T. Chipp; Hesse's "Organ Book," edited by Gladstone; the "Thirty-six Short and Easy Voluntaries," by Dr. C. J. Frost; and the several books of organ pieces by Dr. George Calkin. The latter are very melodious, and many of them are comparatively easy. And then, of course, there is Sebastian Bach. Bach is the king of all writers for the organ. For acquiring technique there is nothing like his preludes and fugues. The "Eight Short Preludes and Fugues" form a kind of school in themselves, though the student had better delay attacking them until they are fairly within the measure of his capacity. They can be suitably followed by some of the large fugues, such as the short E minor and the one in E♭, known as the "St. Ann." As there are many editions of Bach, it is advisable to say that the best is that edited by the late W. T. Best (Augener). Very good, also, though less easy to read, because more crowded on the plates, is the edition of Sir J. F. Bridge and Mr. James Higgs (Novello). Both editions are fingered and marked for pedal where necessary.

After Bach, among the great composers for the organ, comes Mendelssohn, whose little collection of preludes and organ sonatas ought to be on every advanced student's desk. The short movements of the organ sonatas should be taken first, and followed by the Prelude and Fugue in G. The easiest of the sonatas is the one in C minor, which makes a capital study "piece." Among what may be called the minor classics may be recommended the works of Merkel, Guilmant, Wely, Salome, Batiste, and Dubois. Of course, these are merely suggestions for helping the student on his way. A list of "suitable" organ pieces could be made to fill many pages of this work; and, after all, the advanced student is best allowed to consult his own preference, which he can readily do by seeing the music before buying it.

Church Appointments. Ninety-nine out of every hundred students of the organ want to secure a church appointment. This is only natural, for where but in church can the organist make practical application of the art he has attained? There are the big concert halls, of course, but these are among the prizes of the profession, not yet to be thought of by the young player. One great advantage of a church appointment is that the organist secures, as a rule, the full command of an instrument for practice. Indeed, in the vast majority of cases outside the very large towns, this is almost the only way in which a player can get unlimited practice. Even in the large towns it is costly to hire the use of an instrument, and the enthusiast who desires to "get on" will often find it to his advantage to accept a post, when he is competent for it, at a merely nominal salary—nay, at no salary at all—solely for the practice it will bring him.

Generally speaking, the Dissenting churches offer the easier posts for the young organist, the musical services there being so much simpler than in the Church of England. In the village churches the technical requirements are probably about equal, but young players not accustomed to it are apt to find the chanting of the prose psalms and the canticles a difficulty. Still, a Churchman will not readily give up his own "Communion," and after all, granted an adequate competence to begin with, there is much more to advance the player in the Church of England than in the Nonconformist services.

Choir Training. A post in either case is alike in one important particular—namely, that it demands some little ability and experience in choir training. This is a matter which is too often, and very absurdly, taken for granted. It no more follows, of course, that because a man can play the organ he can drill a choir, than it follows that a man who makes billiard balls can play billiards. Every student of the organ who looks forward to a church appointment should make a special point of acquiring a practical knowledge of choir training. It is not a thing that can be gained by reading. The best plan—assuming the student to have a serviceable voice—is to become a member of some church choir directed by an organist who excels in this branch of his art, and watch carefully his methods. The subject of voice production should also be studied, and special attention given to the important side subjects of articulation and expression. A choir *must* be drilled; and the unfortunate thing for the young and inexperienced organist is that the more modest his appointment, the more necessary, as a rule, does this drilling become [see CHOIRS]. Helpful works on "Church Choir Training" and on "The Art of Training Choirboys" are published in Novello's Music Primers series. The student will find it of service to consult also "Common Praise," by F. G. Edwards; "Organs, Organists, and Choirs," by E. Minshall; and "Studies in Worship Music," by J. Spencer Curwen.

A word or two as to the financial side of church appointments. The organist is, as a rule, still miserably paid in England. Especially is this the case in the Church of England, where salaries of £40 a year are common, and salaries of £80 quite uncommon. Often, the sum offered does not exceed £20. In the Scottish Presbyterian churches the salaries are somewhat more in accord with the duties and abilities demanded. Good churches pay from £60 to £80, and salaries running into the three figures are not unknown.

As regards appointments abroad, not much need be said here, because such appointments are generally applied for and obtained by men of experience. South Africa does not offer a very tempting field, unless it be in places of good size, where the English congregate—places like Cape Town, Pretoria, Johannesburg, and Port Elizabeth. The States would seem a better field, for there organists command much higher salaries than the average run in England, though this is largely counterbalanced by the greater expense of living. But the professional can usually take care of himself in these matters. We write chiefly for the amateur, and the amateur organist will probably look rather to the opportunities of his appointment than to its finances.

Service Accompaniment. In the accompaniment of the services, whether simple or ornate, the organist will find plenty of scope for the exercise of his technique and the exhibition of his musical taste. It is hardly possible to teach an organ student to be a really efficient accompanist unless he is endowed with certain gifts in that direction. Much help may be obtained from the works of Messrs. Edwards and Minshall, previously mentioned, and there is also the primer on "Organ Accompaniment," by Sir J. F. Bridge, the organist of Westminster Abbey. In every detail, let the organist remember that the function of his instrument is to accompany, and not to lead, the singing. A player who continually uses the full power of the organ, drowning the voices in a tempest of noise, mistakes entirely the nature of his duties, besides showing a lamentable lack of artistic sense.

Voluntaries. The question of voluntaries is important, not so much from a technical point of view as because of the influence which the voluntary may have in helping or hindering the devotional feelings of the congregation. Broadly speaking, the opening voluntary should be of such a character as will put the people "in tune," as it were, for the service which is to follow. In other words, it ought to be quiet and restrained, without any undue obtrusiveness of technique, without suggestions of secularity. The closing voluntary, on the other hand, may draw upon all the resources of the instrument and all the resources of the player's technique, provided always that it is not in flagrant contradiction to any special character that may have manifested itself in the preceding service. Thus, it would be outrageous to follow an appealing discourse on the sufferings and death of our Lord with some piece of "fireworks" drawn from the flimsy French school. Young players seldom "think on these things;" but they may be assured that these things are of essential importance.

In a large majority of cases it will be safe for the organist to fix upon his closing voluntary beforehand. But he ought always to have some pieces of a varied character on the desk for anything special and unexpected that may have come from the pulpit during the service. As Pope said long ago, some to church repair, "not for the doctrine but the music there," and "a song may find him who a sermon flies." Therefore, give special attention to the question of voluntaries.

Postludes. The young organist who has gone so far with us will have little difficulty in selecting a list of suitable voluntaries. The name of such pieces is literally legion. Opening voluntaries are especially plentiful, and not even a tentative list of these need be attempted here. The player should look up the list of 84 pieces printed by Edwards on pages 189–190 of his "Common Praise." Concluding voluntaries are in slightly different case. Young organists often complain that they have trouble in obtaining short, bright postludes. They find the better-known postludes too long, the church being empty before these are half played. The following—among many others—should meet requirements in this direction: Postlude, A. Boyse; Scherzo, A. Boyse; Minuet and Trio, Baptiste Calkin; Festal March, Dr. Bunnett; Minuetto, G. Calkin; Postlude, G. Calkin; Marches Nos. 1, 2, 4, 5, 8, 17, 18, 20, 21, 22, Dr. C. J. Frost; March in C, Lefebvre Wely; Religious March in E♭, Macfarren; Six Marches, Gustav Merkel; Postlude in C, H. J. Stark; Thirty-six Brilliant Postludes, Dr. Volckmar, in three books; Seven Festival Postludes, Dr. Volckmar.

To these might be added: Postlude in D, Merkel; Postlude in D, Berthold Tours; Postlude in A, H. J. Stark; Twelve Postludes, Dr. C. Vincent; Postludes in C minor, Professor Prout; Introduction and Fugue, E. Silas; March in B♭, E. Silas; Offertoire in G minor, Wely; Homage à Mozart, Baptiste Calkin; Postlude in C, Henry Smart. For those who like marches there is the classical "March Album," published by Augener. Much of Rinck's "Organ School" is eminently suitable in this connection, and, of course, Bach must not be forgotten. Players of modest abilities, who want a single collection from which to draw, can hardly do better than with "The Village Organist" (Novello), of which a long and interesting series has now been published.

Extemporisation. The art of extemporisation, of "creating and performing music at one and the same time," is less practised now than it used to be. It is, however, of great value to the church organist, who has frequently to "create" little bits of music to fill up gaps in the service, to extend his voluntaries or "round them off" in the middle, to improvise introductions to anthems, and so on. It is often contended that extemporisation is a gift; but this is only partly true. Fancy, or the power of imagination, as one has said, is undoubtedly a gift, and to this power the player must turn for the *invention* of his original themes and of the phrases and figures that he will need in the development of his movements. But then, beyond the power of imagination, there is the great power of development on which the player must depend to work out *from* this created theme the completely balanced movement. And *that* is an art which may certainly be attained by properly directed study.

We cannot pretend to "teach" extemporisation here—no writer can pretend to teach it anywhere. At most we can only offer a helpful hint. He who would study the subject practically and in all its details can have no safer guide than Dr. Sawyer's "Extemporisation" in Novello's Primers. The subject is there dealt with in two sections—firstly, the extemporisation of the *theme*; and, secondly, the development of the *movement* from such theme. From Dr. Sawyer the player will learn how to extemporise short preludes and long preludes; how to "vary" a given theme; how to extemporise marches, and postludes, and even fugues, the most difficult of all forms to "create" on the spur of the moment. It need be hardly added that extemporisation implies a thorough knowledge of harmony and musical "form." Many young organists who attempt it are without this knowledge, and so ramble on in an incoherent way, without aim or design of any kind, to the pain and disgust of many who are compelled to listen to them. No effort of this nature can be called extemporisation, since it is not music, which alone "attains its power and effect over mankind by the directness and force it contains in the perfection of its rhythm, the even balance of its parts, and the complete connection of its varied sections." Every organist ought to practise extemporisation in private for a long time before attempting it in public.

Organ Recitals. The player who has been fortunate enough to secure an appointment with the command of a fairly good organ will naturally want to give an occasional recital. Here he has something definite to "work up to," and the knowledge that he is to play a selection of pieces to an audience specially assembled to hear him will stimulate to a greater degree of finish than is generally held to be demanded by the ordinary Sunday voluntary. The art of making up a recital programme is not to be taught on paper. The great aim should be to secure as much variety as possible in the character of the pieces chosen. There ought to be a due admixture of loud pieces and soft pieces; the more severe style (say, of Bach) should be contrasted with some lighter style; a good march might be thrown in, and perhaps a piece which affords the player peculiar scope for proving his command of the technique of his instrument. The solo stops will not be neglected. Thus, if the player's instrument boasts a fine "clarinet" or a fine "oboe," he will see to the inclusion of some piece or pieces calculated to show it off, as the saying is.

The recitalist should try to have a fugue by Bach as representing the most solid of all styles of organ music. A Mendelssohn sonata is also considered the right thing by many organists. Some like a Handel concerto, too—the Fifth and Sixth are the easiest, if the player wants to know. Of the more modern German school, Rheinberger and Merkel are specially commended, though Rheinberger is somewhat heavy for the average recital audience. Of the English school, Smart, Lemare, and Hollins, among others, should have attention. The French school may be drawn upon for the light style, though much of the work of Guilmant, Salome, Widor, Dubois, and others answers to something higher. Batiste and Wely are brilliant and showy, and have the advantage of being comparatively easy to play. Of "arrangements," so called, the number is endless. Some purists condemn these entirely, insisting that recital programmes should be made up exclusively of music specially composed for the organ. But the average audience has to be considered, and an effective rendering of, say, "The Better Land" or the Mascagni "Intermezzo" will often give pleasure where a "legitimate" organ solo would fall flat.

Recital Selections. But the young player who has been so far guided entirely by these lessons may rightly ask us to expressly name a list of recital pieces. Bach and Mendelssohn being assumed, take, then, the following: "Occasional" Overture (Handel); Barcarolle (Sterndale Bennett); Priere et Berceuse, Cantilene Pastorale, and Grand Chœur in D (Guilmant); Fantasia in C (Berthold Tours); Postlude in E♭ (Wely); Cantilene in A minor, Pastorale in G, and Offertoire in D♭ (Salome); Andante Grazioso in G, Quasi Pastorale in G, Tenor Song in B♭, and Grand Festive March in D (Smart); Andante and Allegro in D (F. E. Bache); Offertoire in D minor and "The Pilgrim's Song of Hope"—Andante in G—(Batiste); March for a Church Festival (W. T. Best); Fanfare in D, and Triumphal March (Lemmens); Toccata in G (Dubois); Grand Chœur in A (Salome); Evening Bells (Chauvet); Pastorale in E (Lemare); Communion in F (Grison); Overture in E (Morandi). This, it must be insisted again, is the merest apology of a list. The young organist should see as many recital programmes as he can, in search of further hints. A selection is published every month in "Musical Opinion," and every large town has its experienced recitalists whose programmes should never be missed. At the same time it is, of course, advisable that the recitalist should not be always playing the things that other organists are playing. The choice of pieces is extensive enough to enable every player to be original, if he will.

Some Practical Hints. We close with the practical hint that the organist should acquaint himself thoroughly with the mechanism of his instrument, and learn how to tune it and to "regulate" the defects which are almost inevitable in so complicated a machine. These acquirements are specially necessary in small towns and country districts where a professional organ tuner cannot readily be obtained. The more he reads about his instrument and its repertoire, the more intelligently he will play.

Organ concluded

SCIENCE OR MUDDLE IN SOCIETY?

The New Science of Life. The History of the Race is a History of Mistakes. Society will now Develop Scientifically instead of Muddling Through

Group 3
SOCIOLOGY
1

Following on PSYCHOLOGY from page 3865

By Dr. C. W. SALEEBY

WE turn now, with daring but not without hope, to that great study which is the crown and end and aim and synthesis of all the lower sciences. From a narrower point of view such a description might be applied to the science of medicine in its widest sense, and there is this much of instruction to be gained from the comparison between medicine and sociology—the common explanation of their difficulty. In studying one of the basal sciences, we have no very numerous assumptions. We build our own foundations, and are not at the mercy of criticism from without. On the other hand, there are more complex sciences which depend entirely for their foundations upon the foundational or fundamental sciences. There was no possibility of a rational medicine when chemistry, physiology, and anatomy had no existence; yet medical knowledge was needed, and men had to do their best to acquire it, even though the conditions which made such acquirement possible were unfulfilled.

The New Science of Society. Similarly, the science of society has always been needed by men. Man, as we shall see, is a social animal, and his happiness is gravely affected by the manner of society in which he lives. Thus, as death and disease have always necessitated medicine of sorts, even when the foundations of a rational medicine were non-existent, the needs of human life have always necessitated some kind of sociological practice, even when the foundations for a rational sociology were non-existent, and not even conceived of. Thus, the initial fact, which must surely interest us, is the extreme newness and the very air of novelty which distinguish this science, though the need for it is as old as the human race. Let us first make an inquiry into the history of the word, and then let us consider the foundations and assumptions of the science.

Sociology is a hybrid term, the first part of it derived from the Latin and the second from the Greek. It means simply the *science of society*. Because it is a hybrid, objection has frequently been taken to it; but the word is convenient and intelligible, and has thus come into general usage. It was invented by Auguste Comte, and he had a deliberate intention in compounding it from the languages of Greece and Rome. He tells us that his object was to express the double origin of modern societies, which are, in effect, based upon the practice of the two last and greatest societies of antiquity. The term was accepted in England by John Stuart Mill, who was in some measure a disciple of Comte, and who employs the word in his great "System of Logic" (1843). Subsequently, the term was accepted and popularised by Herbert Spencer, whose work has made it known wherever men think.

Auguste Comte. To the main facts of Herbert Spencer's life we shall devote ourselves in due course. Here our concern is with the idea of sociology as a science; and this is therefore the place in which to make some reference to the philosopher whose name ranks first in this respect. Comte was born in 1798, and early became distinguished for his devotion to learning. When he was still a boy he came under the influence of an extremely remarkable man. Saint-Simon, who was his senior by forty years, and whose relation to Comte cannot better be described than in the words of Mr. John Morley, who is a follower of neither: "The most cursory glance into Saint-Simon's writings is enough to reveal the thread of connection between the ingenious visionary and the systematic thinker. We see the debt, and we also see that, when it is stated at the highest possible, nothing has really been taken from Comte's claims as a powerful original thinker, or from his immeasurable pre-eminence over Saint-Simon in intellectual grasp and vigour."

Saint-Simon had the fundamental idea of applying to social problems the methods of science; but he had not what Comte had in abundance—a remarkably complete and thorough scientific training. This it was which gave Comte the power to carry out the application of what we may call the scientific idea of sociology.

A Philosopher's Religion. We cannot leave this remarkable man, however, without commenting upon the second stage in his history, which dates from the year 1844, when he made the acquaintance of a remarkable woman, who had an amazing effect upon his emotional and moral nature. Says Professor Beesly: "Hitherto, though the ultimate object of his speculations had been to place morality on a firm basis of science, and though, in labouring for that end, he had been animated by a noble, social spirit, he had not professed to be a religious teacher, or to set, in his own person, any special example of a good life. He was simply a philosopher, working out a system which he believed would be of great benefit to the human race, but what he had before recognised as a philosophical truth—that love should be the moving principle of our lives—was now brought home to his heart. And this was fruitful of good."

It was in the second period of his life, thus modified, that he set forth his proposals for the new religion which he called Positivism, and which, though it shows very small signs of converting the world to its views, is yet extremely interesting, and is *unique*, as being an artificial religion constructed, in principles and in details,

by a professed philosopher, who was at the same time an adherent of what we may call the scientific school. Comte died in the year 1857, which, by an interesting coincidence, was the very year that saw the introduction by Herbert Spencer of the word *evolution*.

What Makes a Science? Comte made no contributions to the natural sciences. His attempt to make a new religion has been a most conspicuous and significant failure. His name will be permanent, however, in the history of thought because of his establishment of the first principle of sociology, which is that societies and their ways, their origins, characters, and functions are a fit subject for scientific study. Comte's great accomplishment, then, is the application of the scientific idea to the most important realm in which science can conceivably hold its sway. This is not only the first principle of sociology, but is also the most cardinal truth which it reveals to us; and we must consider it carefully.

At this comparatively late stage in our studies we can have little hesitation in answering the question, What constitutes science? When we assert that there is, or may be, a science of anything, we mean much more than that the facts of the subject in question may be arranged in columns or catalogues. We mean not only that there are facts which may be arranged and classified, but that there is a relation between them; we mean, to take an astronomical instance, not only that the movements of the planets may be stated, but also that they may be explained by means of a law which expresses their common cause; or, again, to take a sociological instance, we mean not merely that historians may describe the conditions of various societies in respect of the status of women, and in respect of their relations to war, but also—which is immeasurably more important—that we may establish a relation between the two sets of facts, resulting in the generalisation, so much insisted upon by Herbert Spencer, that "militarism and a low status of women are associated phenomena."

Natural Law in Society. In other words, to assert that there may be a sociology is to assert that cause and effect are as immutably related to one another in the realm of human life as in the realm of mechanics. It is to assert that causation is universal—which, as we have seen, is in a sense the first, the last, and the only assertion of science. Now, to anyone who has had a scientific training the doctrine that causation and the sequence of phenomena are as true of human life as of mechanics is a platitude scarcely worth saying. The idea of the universality of causation has become a necessary condition of all the thinking of such a person. To labour to demonstrate to him that, even though we do not know them, there must be laws of history and social laws in general, as true and comprehensive and as necessary as the law of gravitation, is to waste one's time. It is as if a player of lawn tennis were to spend an afternoon in demonstrating to a cricketer that the amount of moisture in the ground, the presence of wind, and the spin on the ball were factors that had to be taken into account when playing the game. The cricketer might never have heard of lawn tennis, but he would not require to have these things demonstrated to him. He has always known them illustrated in his own game, and he will take them for granted in any other.

The Mistakes of the Human Race. Similarly, the student of physics does not require to be told that social phenomena are caused, and that a given sum of causes will invariably produce a given sum of effects. He who is already familiar with the composition of forces in dynamics is prepared to study the composition of forces in social dynamics. The first assumption of sociology—namely, that there is or may be a science of society, is in no more need of proof for such a student than the first assumption of meteorology, that, appearances notwithstanding, there is or may be a science of the weather.

On the other hand, many persons approach the study of sociology who have by no means had the intellectual preparation of, for instance, the young physicist. In consequence of this simple truth society has again and again been committed, and will again and again be committed, to the most gigantic and disastrous errors. All over the world the greater part of legislation consists of the abrogation of previous legislation. Human history is a history of error. Its successes have been gained, it will appear, by the method which the logicians call the method of trial and error. There having been no scientific sociology, and politicians having been the same quaint and shortsighted creatures in the past as in the present, men have tried every kind of wrong path until at last, no choice whatever being left them, they have entered the right one. Even then they have only too frequently left it; but, on the whole, truth has a way of prevailing, because truth has the superior *survival value*, or value for life, and so progress, though slow, is yet achieved.

"Experience by Experiment." Now, the method of trial and error is satisfactory enough in some cases—as, for instance, when you are faced with a lock and have three keys in your hand. Even in such a case you waste a little time, but that is all. In no conceivable case can waste of time be dissociated from this method, as contrasted with the scientific method. Contrast, for instance, the behaviour of a baby, who does everything by this method, with the behaviour of even the stupidest grown man, who will not put a key into a lock twenty times too big for it, and who, so far at any rate, is scientific. But, as a rule, the method of trial and error is far more disastrous than in this case. Take, for instance, the doctor of old time who had to treat a disease which he did not understand with one or other of three drugs which he understood scarcely better; as Voltaire said, "Pouring drugs of which he knew little into a body of which he knew less." Here the method of trial and error may well result in the death of the patient, even assuming that one of the drugs be as certain a cure as quinine for malaria.

Marriage and Evolution. Now let us turn from mechanical and medical illustrations to a social one. The method of trial and error has been pursued, for instance, in the case of sexual relations. There were no scientific principles on which primitive men could go, or, rather, such men were as ignorant of these principles as are the pestilent fools who, even to-day, raise their witty and worthless voices against the one sexual relation which the method of trial and error has demonstrated to be sound. In the absence of science, then, this method was pursued by primitive men; though, as we shall afterwards see, the superiority of monogamic marriage is so tremendous that our records of other practices are relatively quite scanty—notwithstanding a popular delusion to the contrary. But observe how imperfect the method of trial and error has been in this case. As in every case, it has wasted time—it has delayed progress; but, just as this method in the case of the ignorant doctor killed most of his patients, so in this case it has killed innumerable races and societies. We have the records of peoples who practised other methods of sexual relation than that of marriage; such peoples are no more. Furthermore, history records not merely the fate of obscure tribes, but also the fate of great nations. Historians in the past may have had many virtues, literary and other, but they have scrupulously avoided being scientific. They have their own theories as to the fall of empires; theories as to racial degeneration—which theories biology knows to be an utter myth; theories as to the corroding influence of peace—which, alas! are so plausible as to have deceived even the profound and majestic soul of Wordsworth—recall the phrase in a great sonnet, "When men change swords for ledgers."

Why Rome Fell. But the sociologist—the only historian who has to be reckoned with henceforth—knows that it is the heart at which an empire rots. He knows that peace and prosperity as such have never destroyed any race. He knows that the decline and fall of Rome, for instance—the same being doubtless true in general—were due to the decline and fall of the family, due to error in this fundamental matter of sexual relation, which we must hereafter discuss at some length.

The conclusion which we desire here to insist upon is, firstly, that the method of trial and error—which we may describe as, in general, the method of all societies in the past and present—is unsatisfactory because the price of error is so terribly high. Much more than this, we would insist that the method of trial and error is a failure because even when success is attained by it, it embodies no sure means for ensuring the persistence of that success. The method has taught many races—all the races that have played any real part in the world—that monogamy is the best sexual relation. They have not been taught it consciously, however, or, indeed, taught it at all in any real sense. The method has merely worked. Yet, when adequate temptation arose, the method has been abandoned—and the decline and fall have followed. How different would be the case of a society which based its practice upon sound sociological principles! Such a society would know, from its statesmen downwards—and such a society would, of course, be blest with statesmen—that the decline of marriage and the family must necessarily be followed by a national decline. Such a society would not go into danger with its eyes shut, as all societies in the past have done.

Sociology is a Living Thing. The truth which we desire to demonstrate might well occupy a volume. There will probably not be a paragraph in this all-important course of which the same might not be said. It is the truth that the recognition of a science of society is necessary for any society which, unlike all societies of the past, is to endure. Now, this is an all-important proposition, and it is very generally disbelieved. There is a common and powerful body of opinion which directly controverts this doctrine. The critics have doubtless some excuse for their criticisms—otherwise less would be heard of them. They incline to the view that sociologists are, in general, a bald, bespectacled, withered-up body of folk, old women of both sexes, who meet in small, stuffy rooms well segregated from the life of men, the full-blooded reality of which they carefully avoid studying, and who spend their time in formulating imaginary solutions for imaginary problems. The presumption, then, is that society will get along as well without the advice of these persons as with it. Now it is true that there is a tendency for every science to become academic and cold-blooded—to manufacture a world of its own and to live in it. It is true, also, that sociologists, who profess to study human life, have less excuse than any other body of scientists whatever for such a foolish proceeding. But sociology, at the present day, is very rapidly freeing itself from the reproach for which perhaps Auguste Comte and Positivism are largely responsible. In this course we shall do our utmost to convince the reader that sociology is a living, warm-blooded thing, and is a fit and worthy object for the study of even young and vigorous folk, who take their full share in human life as we know it. We shall try to demonstrate, indeed, that these, and not those others, are the very persons whom sociology needs and who need sociology. Thus, we can hope to dispose of one of the criticisms which say, in effect, that sociology is superfluous.

"Would Sociology have Saved Rome?" But the illustration of sex relations which we have adduced will serve to meet the further criticism that sociology is superfluous on the ground that in point of fact societies have got along without it. The doctrine for which we here contend is that men have certainly "muddled through" without sociology just as they have muddled through in the past without any science; just as monkeys have muddled through, even though they are destitute of anything that we can call intellect. But we submit that the method of muddling through, which is, of course, one and the same with the method of trial and error, cannot be regarded as ideal by any sane person,

and that, even though it has achieved, by a purely unreflective and unconscious process, the advance of mankind *thus far*, yet an intelligent method would have achieved infinitely more progress in the same time, and would have averted a sum of human misery which it is indeed well that our imaginations do not permit us to realise. We have chosen a notable illustration, furthermore, which shows the difference in worth between a social practice arrived at empirically—that is to say, by the method of trial and error—and the same practice arrived at scientifically. The mechanical process of natural selection, or trial and error, instituted marriage in Rome; nevertheless, Rome fell. How different would have been the result had the same institution been established, not merely by natural selection, but also by the conscious, scientific, and popular recognition of the place of marriage as a necessary foundation—*the* necessary foundation—of any stable society.

Science versus Muddle. We shall have to write many pages concerning the all-important question of Natural Selection, which pervades the whole of sociology because it pervades the whole of life. We shall have to show that its sway is absolutely omnipresent and ceaseless. Nevertheless, we can here and now justify what we have said as to the value of sociology, even on the principle of natural selection. It is true that natural selection, trial and error, "muddling through," will achieve great things if you give them unlimited time and care nothing for the appalling cost. But after morality itself, incomparably the most valuable thing which natural selection has selected and preserved is the intellect of man, which has been "evolved by and *for* converse with phenomena." This magnificent product of natural selection, enabling us to construct sociology, enabling us, for the matter of that, to make fires, build wheels and houses, sew clothes, prepare food, and so on and so on, is also one of the characters of living men over which its producer—natural selection—holds sway. Thus, of two rival societies, one of which swears by "muddling through" or by the purely mechanical method of natural selection in its social practices, while the other believes in science and in the value of principles, and recognises that the best result of the old method of "muddling through," or mechanical selection, is the emergence of the intellect, which is able utterly to transcend this method—which of these societies do you think that natural selection will select?

History a Colossal Series of Experiments. Indeed, we may say that the chief value of the age-long method of trial and error in social matters has been the provision for the modern intellect of material from which it may infer the great sociological truths. From this point of view of a subject which may be looked at from an infinite number of points of view, we may—somewhat selfishly, perhaps—regard the whole past history of man as a colossal series of vast experiments, conducted absolutely regardless of cost and without any limitation of time.

If sociology be a science, it must be subject to the methods of the other sciences. It must begin with facts—the facts of observation and experiment. Now, you may make at a cost of a few pence a physical or a chemical experiment which may be crucial and may alter the whole aspect of your science—for instance, Galileo's experiment of dropping two balls of different weights from the leaning tower of Pisa. But the more complex your science the greater the cost of your experiment.

The Great Need of Facts. At this moment medicine could make the most gigantic advances within a few days but for the cost of the experiments that would be necessary. One would need merely half a dozen criminals, and *carte blanche*, to settle once and for all, for instance, the true relations of tuberculosis in man and in the lower animals. But the cost is too high, for it involves the lives of men and a danger to morality.

In sociology, which is immeasurably more complex than even medicine, the cost of the experiments is higher still. The question of the utility of marriage could be settled once and for all by, let us say, abolishing marriage in England for the next generation. But, obviously, the cost of such an experiment in the lives of men and women and children, the cost employed in the destruction of the race, which, after all, is still in the van of progress, would be too high. And yet, since sociology is a science, it is in need of experiment. What we should like to have is an adequate array of facts of observation and facts of experiment. From these, as in any other science, we should proceed by the process of induction to derive certain generalisations or principles or laws.

A Wonderful Thought and a Tremendous Fact. Nowadays the engineer does not build a bridge that he thinks should be strong enough, and then run a train across it and make a note in his pocket-book that the bridge cracked or did not crack. The engineer is a trained physicist. He has principles on which to work, and he knows that, under given conditions, a bridge of a given structure will be necessary. If those conditions persist, the bridge which he builds does not crack. This is evidently a highly satisfactory result of science. If, then, we were able to derive sociological principles from sociological experiment, as the physicist derives physical principles from physical experiment, then the statesman and the social reformer would be able to build sound social structures at the minimum cost in time and life, just as the engineer is able to build sound bridges without first of all constructing a dozen bridges that crack and throw trainloads of men and women into the water. If only, then, we could make the necessary experiments!

But the tremendous fact is that all the important experiments have already been made. It is one of the greatest achievements of sociology to have made this discovery.

Continued

BOOTS AND SHOES

The Evolution of Leather Footwear. Varieties of Boots and Shoes. The Materials and Tools of the Shoemaker

By W. S. MURPHY

EVER since mankind began to live in settled communities the shoemaker has been recognised as a craftsman whose skill was an asset of the commonwealth. The reason is plain. Men may play or hunt with naked feet, but without shoes they cannot do constant labour or endure the life of the town. Wherever there are cities, there you see some sort of foot covering. Out in the wilds of Nature, amid rocks and thorns and storms, the foot needs no covering; it adjusts itself to environment like other organs, and even develops to fine perfection in the process. Civilisation, however, brings conditions too insidious to be resisted by mere strength of muscle or vitality of blood; the dust of the street pollutes where the soil of the valley falls away innocuous; the regular tread of industry wears the feet.

The first form of foot-covering was a sole fastened by thongs round the toes and the ankle. The sole is the foundation and yet remains the most important part of the boot. Climate and other circumstances determined the materials and shapes of soles in early civilisations. The bark of trees, plaited reeds, raw hides of animals, and flat pieces of wood, have been used in the making of soles. Some specimens of those early foot-covers have survived in Egypt, and are to be seen in many museums. Egyptian sandals are composed of plaited straws of papyrus, and very neat the work of those ancient craftsmen is.

Beginning of the Craft. The bare sole was not a very efficient protector to the feet; sand and grit got between the foot and the sole, and made things rather uncomfortable for the wearer, so a ridge was run round the sides of the sole. This was the real beginning of the shoemaker's craft. Another step in the development of the shoe was the padding of the sandal heel. Some very ancient sandals show the heel fixed on the flat sole, and others have sides without heels. These facts prove that the Egyptian shoe was a natural development, growing up irregularly, as natural growths do. One sandal-maker would think that a heel pad was required to make the sole last longer and be more comfortable to the wearer; another sewed a protecting ridge round the heel and along the sides of the foot, to keep out sand and small stones. Perhaps for a century or two the heels and the sides were distinctive marks of two kinds of sandals worn by different classes of people. At a period in the misty regions of conjecture, the two features were combined, and a sandal that was almost a shoe evolved.

In the earliest record of human life we possess the shoe appears as a finished piece of craftsmanship, not as the production of amateur labour. Historians of the trade never fail to refer to a remarkable painting, said to date from 1495 B.C., on the walls of Thebes, in which shoemakers are depicted at work, with their tools on the space beside them. It is very remarkable that in this painting the awl, the bodkin, the wax and the thread are represented. Even at that early time the shoemaker chose and formed his tools; how well he chose, the fine efficiency of the awl bears witness.

Footwear in Olden Days. The warm climate of the East renders the higher quality of boot unnecessary. A shoe, very little in advance of that worn thousands of years ago, is still worn by Eastern nations. Slippers and even sandals are the fashion among populations which can hardly be described as either poor or barbaric. It is to the Northern peoples, who work hard and build great cities amid changes of climate too severe for the naked feet, that we must look for the evolution of the leather boot and shoe. The Greeks made shoes which came well up the sides of the feet, and were fastened by numerous thongs. But it was when the Romans began their conquests in the North that strong boots covering the whole foot came into use.

For marching in the wild forests over rocky ground, the Romans devised a boot, called the *calceus*, and studded the sole with flat-headed nails. Our present-day Army boot is not far from a likeness to that boot. The Goths and Celts, whom the Romans conquered, had already evolved a kind of hide foot-covering with a sort of legging strapped on their lower limbs. Under Roman rule the Saxons, Franks, and Britons learned to make shoes, and some of the products of those ancient craftsmen show a talent quite artistic. The shoemaker became a fixed institution in all the villages of England, and when the governing powers had settled who had the strongest right to rule over the country, we find him everywhere, from the Tees to Southampton Water, plying his craft.

To the shoemaker the age of chivalry, so-called, was an era of queer boots. No more fantastic collection of footwear could be imagined than the boots and shoes of that period. Boots of steel plates, boots of chain mail, long-pointed boots, gold-mounted bell-girdled boots, boots and shoes made of leather, cloth, and all sorts of materials—every variety conceivable were made and worn.

The Evolution of the Boot. About the end of the fourteenth century, boot fashions began to evolve somewhat in the direction of rationality and uniformity, and gradually the

long-legged boot, extending to the thigh, came to be the fashionable footwear for outdoors. This was the real boot; the articles we now call boots would hardly have been dignified by that name by the original bootmakers. The sea-boots worn by old-fashioned fishermen are the sole surviving specimens of the great boots. Step by step the boots were modified, and the jack boots, a refined model of which is worn by the Household Cavalry of the British Army, came into vogue. About the middle of the eighteenth century the heavy heels and strong leather tops hampering the knees went out of fashion with English gentlemen, and the form now called top-boots, and worn by postilions, footmen, and liveried coachmen, was adopted. Gay boots they were, with yellow tops and lacquered legs and fronts.

Wellingtons. The great Duke of Wellington, with his stern practical sense, ordered his boots to be made short in the leg and fit to be worn under his trousers. The great leader's idea at once caught on, and everybody adopted the Wellington boot. Up till this time knee-breeches were the dress for men; but trousers became the common vogue, and with that came a modification of boots. With trousers the long leg of the boot was unnecessary. Ladies continued through all that long period wearing shoes, sometimes with high heels, sometimes with pointed toes, at one time plain and at another extravagantly ornamented, the uppers of a variety of different materials, but always with leather for the soles.

Dress Boots. At home, in the dining-room or in the parlour, the gentlemen also wore fine shoes, of light leather, with buckles of fantastic shapes and styles. When the military and hunting professions of gentlemen ceased to be of so much importance, and peaceable pursuits brought wealth, the shoe took the place of the boot, and from about the middle of the eighteenth century on to the middle of the nineteenth the buckled shoe gradually drove the boot out of fashion. With the advent of the trousers, as we have hinted, the shoe gave place to the boot, and even on the shoe the buckle was superseded by the tie or lace latch.

Working-men's Footwear. While these changes were going on in fashionable circles, the footwear of the working classes also was altering. Large sections of the poorer people never wore boots except on Sundays, and then it was a pair of large jacks or tops handed along from one member of the family to the other, or a single pair was got by a man when he was full-grown by scraping pence together, and made to serve his lifetime. In some districts, clogs—shoes with thick wooden soles—were worn, and as money became more plentiful among artisans they sought to imitate their social superiors by patronising the shoemaker, who made them an inferior kind of buckled shoe. On the other hand, in some districts the fashion of wearing boots of a good quality never went out, because the shoemaker rose or fell in status with his fellows of the town or village.

Changes in Fashion. During the latter half of the nineteenth century successive waves of change swept over the boot trade, effecting a complete revolution, which, because gradual, was scarcely noted outside the trade itself. The Wellington, the Blucher, and other forms of long-legged boot went out of fashion, and for a time the shoe, the lacing boot, and the elastic-sided boot struggled for the market. The elastic-sided boot was a solid upper coming well above the ankle, sections of elastic cloth being let into the side to give the boot grip on the foot. By the year 1880 the battle had been decided wholly in favour of the lacing boot—that is, a boot with open front, closed over the foot by drawing a lace of leather or silk or cotton through ringed holes along the edge of the two sides of the opening, the top coming over the ankle.

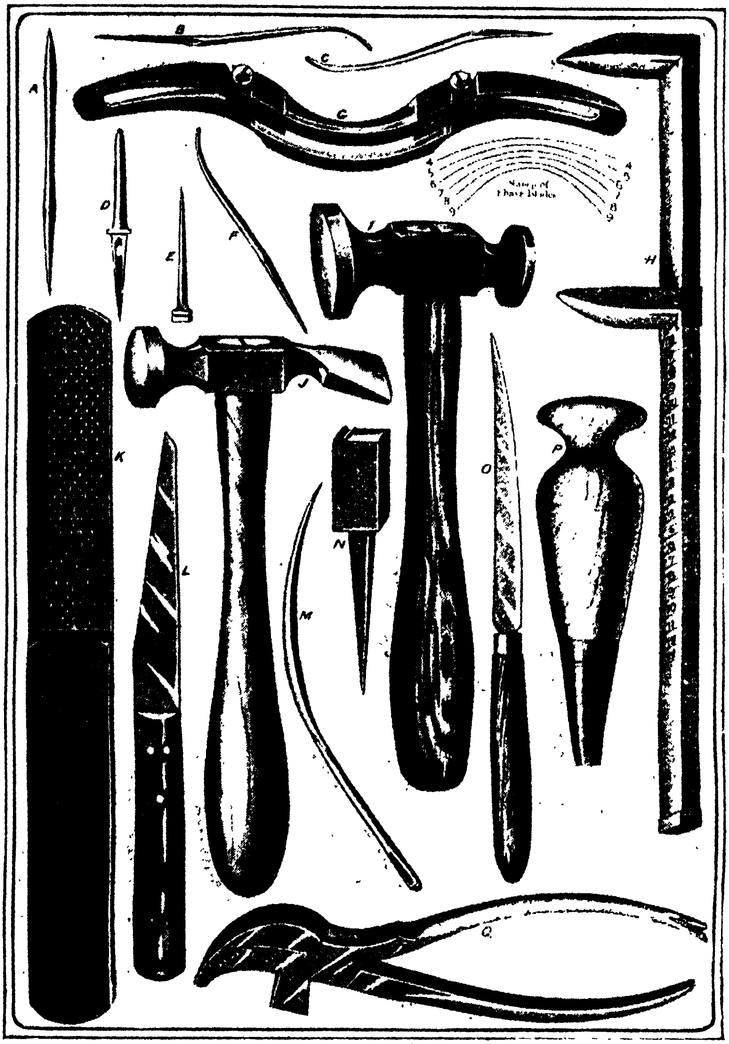
Enlargement of the Boot Market. Contributory to the success of the lacing boot was the advent of boot-making machinery. Before looking at that tremendous event, however, we shall glance at the social factors which helped the change. Within the last thirty years of the nineteenth century the mass of the British people became a boot-wearing population. Previous to that time, country people seldom wore boots in the summer, and children, in the North especially, ran about barefooted till well on in the autumn. At the beginning of the twentieth century all this had changed. Except among the poorest, every man, woman, and child adopted the habit of wearing boots winter and summer, and generally had one kind of boot for each season. Industrial conditions made boots absolutely necessary. Town life further increased the need for boots—boots strong and serviceable, easily put off and on.

Customer and Shop Boots. With the increase of wealth in the country the standard of life rose all round, and the result was an increase in the demand for boots among the working class. To meet this large and not too critical mass of custom, the ready-made boot trade sprang up. For a time it seemed as though our craft was to be split in two; a great cleavage seemed imminent between what we call the bespoke and the shop trades. In the bespoke trade, the boot buyer comes in and gets his foot measured, and the boot is made up exactly to the size and shape desired; for the shop trade, the boots are made up into sizes, and the customer buys the boot of the size and pattern that fits or otherwise suits. But the cleavage has not taken place. The ready-made boots have improved in quality and gradation; the bespoke trade can be done in the factory. The handicraftsman has been almost put out of existence.

Division of Labour. Among the millions of boots worn to-day, scarcely one pair in a thousand has been made by hand; the great boot producer is the factory. The division-of-labour principle has gone through all productive industries, dividing up trades into parts, and setting separate groups of workmen to each detail. In shoemaking, the preliminary step was accomplished a good while before the factory was

thought of. Very often two partners or brothers, or father and son, or husband and wife, divided the making of the boot between them — the younger or more refined taking in hand the top or upper, while the other sewed in the sole and finished the boot. It is easy to see how this could be extended and the partner become employee. The shoemaker supplies the leather, all cut, to the upper-closer, and pays him so much for the work. As his trade grows he employs another bootmaker and another topmaker, and soon the workshop grows into a factory. The cutting of the boot tops is given over to a workman, called a *clicker*, who does nothing but cut tops and linings; the linings are given to one worker, generally a woman, and the leather fronts to another; they are separately sewn, and to one worker is given the duty of putting them together or *joining*. Similarly, the laying of the insole and the sewing of the sole are separated. Then came the sewing machine.

Boot Factory. The advent of the sewing machine marked the beginning of a new order in the bootmaking trade. The handicraft had been broken up into small details, to each a separate workman or group of workmen; but as yet the whole process was carried through by hand. But by quickening production in the top department, the sewing machine set the pace for the whole factory. Bootmaking by machinery was bound to come. How it came we shall see.



29. SHOEMAKERS' TOOLS

A. Straight awl B. Curved awl C. Curved awl D. Peg awl E. Lasting tack F. Heel awl G. Heel shave H. Size stick I. Hammer (double-faced) J. Hammer K. Rasp L. Shoemaker's knife M. Curved awl N. Edge iron O. Clicker's knife P. Awl haft Q. Lasting pincers

Making Boots by Hand. Bootmakers have been blamed for making boots that cramped the feet, deformed the toes, raised bunions, and even reduced the mental energy of the unhappy wearers. We emphatically deny that the blame for unhealthy shapes of boot can be laid wholly on the shoemaker. We are the servants of the public, and if the people have a craze for pretending to each other that their feet are more slender or smaller than they are, boots must be made according to the dictates of that craze. Many a man has lost a good customer because he has tried to resist the foolish desire for what a perverted taste calls neat feet. No shoemaker with a proper respect for his honourable craft will blindly copy the models set by ignorant fashion. He has, however, to make his living in a world where nothing is perfect, and meet, if possible, the wishes of his customers. The desire to have a neat foot and a graceful carriage is as natural and right as the love of beauty itself. Boot reformers are apt to forget that grace is also worth considering; a healthy boot need not be also an ugly boot. The three leading qualities of a boot are these: (1) It clings to the foot without cramping it; (2) it wears well in all parts; (3) it is graceful in appearance and shapely.

Structure of the Foot. The bootmaker should never forget that the foot is a living organ

he is commissioned to cover. If the trade was thoroughly organised, no man would be allowed to make boots or shoes unless he had passed an examination showing that he possessed a good knowledge of the anatomy and structure of the human foot. The boot is made for the foot, not the foot for the boot. Knowledge of the foot would tend to induce a proper reverence for it. No more wonderful structure has been created. It is impossible in this work to give an exhaustive description of the foot, detailing all the bones, muscles, blood-vessels, and nerves of the organ. A standard work on anatomy must be consulted by the student.

Bony Structure. The structure of the foot is composed of 26 bones, so disposed as to form an arch, the back pillar of which is the heel bone, and the front is supported by the toe-joints. Above the heel bone is the bone called *astragalus*, which is the key bone of the foot. It fits into the bottom socket of the leg bone, puts the pressure of the body on the heel, and at the same time distributes the force forward on to the arch bones, and thence to the toes. The central arch bone, named the *scaphoid*, is connected with the heel bone by an elastic ligament, and is touching the key bone, while connected forward with the three bones from which the toes spring. The toes come out from the metatarsal bones, the large toe having two phlanges, the other toes three.

Muscles. Very important is the strong muscle extending from the inner extremity of the heel bone to the five metatarsal bones, forming a kind of tie beam to the arch of the foot, and bracing the structure together. The structure is further held and strengthened by the muscles coming down from the leg and ending on the bones which form the joints.

As we have seen, the astragalus forms with the tibia and fibula the ankle joint, the inner joint with the heel bone, and the forward joint with the arch bones in front. This gives flexibility to the foot. There are three sets of muscles of prime importance: (1) The muscles of the calf, attached above to the bones of the thigh and the leg, and below by the Achilles tendon to the heel bone; (2) muscles coming from the tibia to the main arch bone; (3) the muscles from the fibula to the outer frontal bone of the foot. By means of these muscles the main movements of the foot are energised and controlled.

The Fitting of Boots. The other and smaller muscles, the blood-vessels and nerves, have also to be considered by the bootmaker; but detailed study must be carried on further in other ways. Enough has been shown to indicate clearly the main structure of the foot. It is obvious that respect must be had to bones, joints, and muscles here indicated by the maker of boots. To make an arch to the instep too high, pleasing to vanity as it may be, is to injure the great muscle upon which the whole grace of the foot depends; to narrow the boot across the instep is to squeeze together the lower bones of the arch and reduce the foot to the condition of a club. We insist upon it, that all those efforts after grace which limit the free play of the foot in all its parts defeat themselves.

Tools and Materials. A shoemaker's equipment [29] is not small. In these days of continual effort after improvement there have not been wanting temptations to the shoemaker to abandon the time-honoured tools of his craft for new, and perhaps handier instruments. We prefer to stick by the old range of tools, because they are the foundation of all departures, which are various. In one town or district one kind of new tool is taken, and in other places another set of improved tools are accepted.

The Bench. The two most conspicuous pieces of furniture in the shoemaker's shop are the bench and cutting-board. In construction the bench is a box 4 ft. long, 2 ft. by 2 ft. the top and inside divided into two sections. One half is covered by a padded leather seat, and the other is compartmented into boxes, in which are kept wax, tacks, sprigs, and various kinds of smallware. In the vertical division of the bench to the right of the shoemaker as he sits we find two drawers, the top one of which contains balls of flax or hemp thread, and in the lower one measures and notes on customers' boots.

Places of Tools. The division under the seat is usually occupied by tools not in immediate use, and small pieces of leather which may come in handy for packing. Along the wall behind the bench is a rack holding in leather sheaths the range of awls and knives constantly required in work. To the left is an iron table, with smooth top, and on the bars under it are several lapstones. On a rack in the middle of the floor hang over a hundred lasts of sizes ranging from the child's to the full-grown man's foot. Beside the last-rack stand thick logs of various lengths, in the top end of which are stuck what look like iron feet.

Awls. This is a general view; but we must look closer and learn the character of the tools we have to handle. Some of the awls [29, A to F] have long handles shaped for grasping; but look at the blades. They are of the finest steel, and curve curiously to the double-edged points. Straight at the handle, the curve of the steel aids the thrust of the worker as he sends it through the hard leather. Other awls are straight and flat on the head; these are meant to be driven direct through the leather by the stroke of the hammer.

Punches. Next are short-bladed piercers with stout handles, for making the holes into which the sprigs or tacks are driven. Three pairs of punches, one with a needle-like point, one larger in diameter, and the third larger still, hang ready to make the holes in the boot-tops for lacing rings or ornamental patterns on the toecaps.

Setting Irons. While we think of ornament, the setting irons [29N] are to be noted—curious steel blocks, one side with edged ridge, and set in strong handles. Along with them we

find what look like spur rowels stuck in handles, little wheels that impress the leather with a pattern—some a line of points, others wavy lines, and named *stitch-prickers.*

Knives. Then there are the knives, a perfect arsenal of blades. One broad piece of steel has a point curving out from the face of the blade; another, shaped like a crescent with a handle coming from the inner centre of the curve, is the skiving knife; and others of various sizes are straight, business-looking cutters. All are kept sharp as razors by the stones near at hand. The catalogue is long, but the shoemaker's tools are many. In addition to these, he has hand mittens, knee belts, waxes (yellow, brown, and white), emery-cloth, sandpaper, rasps of different degrees of sharpness and size, bristles that make needles for his threads, polishing-black bottle, and polishing shaft.

The Topmaker's Tools. Where the shoemaker has an upper or boot-top sewer in partnership with him, they hold the most of the tools in common; but the sewer has his or her bench, and a set of fine awls, fine threads, a closing clamp or board that holds the top in its jaws while the sewer works, and, in newer shops, a sewing machine for linings and light leather.

Materials. Our materials are not so numerous as the tools; but they are sufficiently varied to confuse the beginner, unless he has some warning of what to expect.

Sole Leather. Sole leather is thick, hard, heavy, and very stiff. It comes to us in hides, and may vary a good deal in weight and quality. Before the clever chemists came to teach the tanner how to play upon the hides, it was comparatively easy to tell the different qualities. The best qualities had a buff colour, and could be worked to the hardness of iron without fear; the lower qualities tended to red in colour, and kept soft in spite of all the hammering in the world. Leather may now be of perfect colour, and send flakes and splinters from under the beater before the sole has been shaped; red leather may turn out quite good.

Tests. Adulteration of leather has been very common of late years, weighting of the hide with glucose or sulphate of baryta, a kind of earth, being the most frequent. For discovering the latter, you have only to draw your knife sharply through the edge of the leather and the earth will rasp on the edge like sandstone. Glucose can be detected by laying two pieces of the leather in a damp cloth and leaving them overnight. If the pieces are sticking together with a soft, syrupy substance between them, glucose is present. There are other ways of faking leather, but if you buy from a good tanner, and there are many, you are sure to get a fair quality for a fair price.

Top Leather. Next in importance is the stock of top leathers. These vary in thickness from the heavy hide for making the uppers of stout working boots, boots for hunting, deer-stalking, mountaineering, and the like, down to light calfskins or glacé kids, for fancy boots or ladies' wear. Then there are a good many patterns — plain, grained, pebble-grained, diamond-grained, or pigskin-grained [see plate facing 3217]. Patent leathers—morocco, russia, and roans—have to be stocked for fine edgings of high-class boots and shoes, toecaps, or fronts of ladies' slippers. Going on from heavy to light, we come to wash leathers, split sheep, calf and goat skins, for linings and bindings. Light pieces of hide called offal by the tanner are needed for insoles and packing.

Fine Leather. Experience alone can teach a man how to be independent of the honesty of the leather merchant in dealing with those top, fine, and fancy leathers. Of course, he must learn, and that very quickly, to tell the difference between a pebble-grain and a box-grain, or a roan and a russia leather; but that is not a difficult matter to an intelligent person.

Various Materials. The independent shoemaker has to stock a good deal of ironmongery and drapery, which must be judiciously and carefully stored. Linings of cotton, linen, canvas, felt, and cloth, straps of mohair, flax, and cotton; soles of felt, cork, canvas, and pasteboard fill up a good many shelves and drawers. Wood pegs, brass and iron rivets, sprigs, sparables, hobs, heel-plates, toe-plates, boot-protectors, rubber heel-plates, eyelets, buttons, and patent fasteners of many kinds—all these fill up the drawers and stock boxes of our workshop, and absorb a lot of capital.

Our inventory of bootmaking materials is general; there are many things used by specialists we have barely noticed. The things enumerated are common to the whole trade, and should be known to every craftsman. We hold strongly to the opinion that the beginner ought to be taken through the stock-room and shown every tool and material of his craft, with explanations of their uses. This is the main intention of the present section of our course.

Continued

CYCLOPÆDIA OF SHOPKEEPING

MOTOR-CAR DEALERS. Prospects of the Business. The Garage and its Requirements. Prices and Profits. Motor-car Repairs

MUSICAL INSTRUMENT DEALERS. Training. The Importance of Tuning. Buying and Selling. The Hire-purchase System

MOTOR-CAR DEALERS.

The time when the selling of motor-cars can fairly be included under the term shopkeeping has not yet arrived, but something of the possibilities of the business may be discussed, if only in the light of intelligent anticipation. The difficulty does not lie in the actual selling, but in the circumstances attending the newest of our industries. The fact is that the manufacturers of motor-cars are not anxious to enlist the services of the middle-man at present. The public is in no mood to purchase otherwise than direct from the manufacturers, or, if the car be of Continental make, from the first-hand agent in this country, or of the importing firms.

Cycles and Tricars. This statement, however, hardly applies to tricars, and certainly not to motor cycles. The latter have already been reduced in price to reasonable figures—there are now good machines to be retailed at about £30—and many agents have done well by investing in a single machine, by riding and showing which they have been able to dispose of others in large enough numbers to make a success of the business. A good many riders prefer to buy a machine which has been "tuned up," and it is certainly a promising risk to buy a motor cycle on the chance of disposing of it in due course. Practically this way of doing the business is the only likely one at present.

Motor cycles and the profits which they carry are discussed on page 2094. The profits on motor-cars are not as satisfactory upon a percentage basis as are those of the motor cycle. On tricars, which are made by cycle manufacturing firms, the inducement is fairly good, being up to £25 profit per car, and occasionally more, but on the heavier vehicles the prospect is less enticing. Ten per cent. commission, and sometimes 15 per cent., is as much as motor-car manufacturers will allow to the agent. If business can be done without holding stock, and if the customer pays cash, orders are, however, well worth seeking.

There are good profits on accessories, some of which are subject to 30 per cent. or more discount.

Small Cars. The three-wheeler, or tricar, holds the field at present, but sooner or later it seems destined to be displaced by the car on four wheels. At from £65 to £105 the tricar is dear, and in the matter of maintenance is not so economical as a four-wheeled vehicle. Already there are a few of the latter type to carry two persons purchasable at or about £100, and it is safe to predict that five years hence buyers will find a choice between half a score at or below that figure. When that time comes the agent in a small way will get his chance. With more competition the makers will be keener to have his co-operation.

The present system of deferred payments will be modified so as to enable agents to profit by introduced sales. As things go now, commission on deferred sales is rather grudgingly accorded because they are rare; for, as we have seen, the buyer goes direct to the maker.

Prospects. At present high-power cars are very expensive, and, indeed, unreasonably so compared with other work involving the same class of workmanship and similar materials. The makers, of course, have a good case in the argument that the initial expenses have been enormous, and therefore that the whole of these high profits must be secured to themselves at present. Later on this cry will no longer be tenable, and then all will be altered—motor-driven vehicles will be designed for the lightest classes of business, and a big industry on sound business lines will be developed. This will displace the present necessary but not altogether desirable system, which has opened the door for a whole round of commissions to the friends of buyers, who are not always disinterested in tendering advice. Moreover, as things stand, "oiling" the drivers is alleged to be inevitable, and thus the agent is not unnaturally a little shy of the whole business, which, under any conditions, involves the investment of considerable capital.

The Garage. Still, something can be done. As we have already shown, business is possible in small cars and motor cycles, and there are openings in many towns for the starting of garages where cars can be stored, accumulators charged, repairs undertaken and accessories retailed. Of course, in every such establishment motor spirit and suitable lubricating oils must be stocked, and although the profits on these are low, and the conditions under which the former is stocked are somewhat onerous, these commodities bring other business, and cannot be ignored.

The first provision of a garage is an inspection-pit, which must be brick-lined. The best dimensions for this are 42 in. width and 54 in. depth. The length of the pit depends on the building, but it should be not less than 6 ft. The brickwork round the top edge should be rebated, to afford a 2 in. bearing for a 1¼ in. wood cover. If expense be not a serious item, steps at one end are well worth including in the scheme, and drainage of some sort will be

necessary. If there happen to be any difficulty about making connection with a drain, as might be the case in a country district, a hole 3 ft. deep at one corner, half-filled with shingle and coke, and covered with an iron cover, may answer, although obviously such a plan will involve periodical cleansing and renewals of the coke, etc.

Garage Equipment. The usual precaution of not having a naked light in the motor-house must be stringently observed in respect to the pit. If the electric light is not available, only a Davy lamp should be permitted in the place.

The agent who undertakes repairs and does them in his garage will have to face the problem of heating the building in winter. The ideal plan is to sink a small boiler-house or lean-to outside the main building, and to install pipes or radiators inside the garage. The absolute necessity of some such provision will be appreciated after a sudden drop in the temperature during the night, resulting in a cracked water-jacket in a customer's car.

Another special apparatus necessary will be the vulcaniser. This device for repairing cuts and bad places in the tyres will cost the agent from £3 upwards. There are several patterns on the market. Most of them depend for heat upon steam, generated by a gas jet, or a blow lamp ; but in one at least the heated surface is derived from iron blocks which can be made hot in a forge.

The third essential feature in the agent's garage will be the provision of means of re-charging accumulators for customers. The agent who can command the use of current from electric mains will do so. The cost in that case will not be serious, for a charging board is not an expensive affair. If the district is outside the area of any of the electric supply companies, a primary battery and resistance board will have to be installed.

Repairs. The would-be dealer in cars and motor cycles must cultivate the repairing business. First, if he be a fitter or mechanic he might get employment in a garage, where he would have opportunities of learning something of the mechanism of various cars. With the knowledge thus acquired, and if he can command the use of £100 or £200, he can take premises, build his own pit, put down a lathe, grinding machine, drill, electric charging and vulcanising plant. There is available to the man who wishes to perfect himself in the knowledge of motor-car details a considerable volume of literature which is by no means expensive. Mr. Worby Beaumont's book on the subject is, of course, the classic, but as it costs about two guineas it will not be within the reach of the individuals we have in mind. However, from the list which follows he will be able to select suitable and helpful books. Mr. Douglas Leechman's "Autocar Handbook" (215 pp., 102 illustrations), costing only 1s. 6d., contains plenty of elementary information about the motor, and something about the châssis and gears. It is published by Iliffe & Sons, Ltd., of Coventry and 20, Tudor Street, E.C., which company also publishes a capital handbook on "Motor-Car Repairs," at 2s. 6d., and a third publication, "Useful Hints and Tips for Automobilists." The last is a collection of more than 500 hints reprinted from "The Autocar," which is the leading weekly (3d.) connected with the sport and industry. A more expensive book is W. Poynter Adams's "Motor-Car Mechanism and Management" (174 pp., 22 diagrams). Only one part, dealing with the petrol car, has been issued up to the present, but others, treating of the electrical car and the steam carriage are promised. Each part costs 5s., C. Griffin & Co. being the publishers. On the very intricate subject of ignition, the Cycle Trade Publishing Co. have published T. H. Hawley's "Motor Ignition Appliances" (137 pp., 43 drawings). It is an exasperating book to read, owing to the long and involved sentences affected by the author, who, however, covers the ground well, and gives the purchaser a generous half-crown's worth.

Finally, we may mention "Petrol Motors and Motor-Cars," by T. Hyler White (187 pp., 44 diagrams). Longmans, Green & Co. publish this at 4s. 6d., and it may best be described as the handbook of the designer and draughtsman. The principles underlying construction, with the formulæ for determining the correct proportion of the engine details, brakes, transmission gear, etc., are discussed in this eminently practical volume.

With a moderate capital, some experience, and a determination to master the principles upon which a car works, a start could be made which might be expected to provide a moderate living at once, and to furnish the basis on which to build up a successful business in the near future. What we wish to point out is that the practical man has a better chance of making a success than his fellow who has been engaged only in buying and selling, and whose early training has been along commercial, rather than mechanical lines.

MUSICAL INSTRUMENT DEALERS

Under this heading is comprised the shopkeeper who deals not only in musical instruments and their accessories, but also in sheet music.

Many a now profitable music business has originated in a private house. The reason for this is that the first essential for success in this special sphere of commercial activity is a practical knowledge of the business. The second desideratum is care in bookkeeping. A good accountant has often succeeded where the purely practical man has become bankrupt. In Great Britain a beginner with small capital should avoid attempting to startle his neighbourhood at the outset. The tyro has not much choice as regards a site if he purchases the connection and goodwill of a going concern.

Apprenticeship. There is no type of business misunderstood more often than is that of the music-dealer. If a young man, or a young woman, show musical aptitude nowadays, and be a failure in a professional sense, he or she is considered qualified to open a music-shop. Such establishments are soon closed. The best recipe

against shipwreck is to be the son of a successful music-dealer and to have profited by his experiences. But, for those unable to select the occupation of their parents, the best way to ensure success is to have the training of a piano-tuner and be possessed of good credentials from a firm of standing. In old-established London factories to-day lads are indentured as apprentices for tuning at the age of fourteen. The apprenticeship period lasts from five to seven years. The usual procedure is for a lad to go to a recognised firm and offer his services in return for tuition in piano-tuning. In some factories a small remuneration is offered to the apprentices, but in the majority of cases the beginner works for no pecuniary reward. An apprenticeship in a piano factory is desirable for learning piano-tuning properly, not so much because the lad gets to know the internal mechanism of different types of pianos but he has constant practice in actual tuning all the time. Some historic makers charge premiums for apprentices, and if the youth's parents can afford it, the expense is justified by the experience gained.

Assistantship. Apprenticeship over, the next step for the youth is to get a position in a retail music shop as an improver. There (where probably he will be paid £1 a week) he will have old pianos as well as new ones to tune, and he will learn from the old instruments many matters he has no opportunity of discovering at the factory. Moreover, he gains experience of retail business methods, and after two years should be competent to serve as what is known as an "outdoor tuner." When such skill is attained, the next move is to get the employer to send him out to tune the pianos of customers. It is understood that the shop selected for the improver is one in which not only pianos but musical instruments of all kinds are sold, and sheet music as well, so that, while advancing in piano-tuning—which, after all, is the main thing—he is also learning other necessary departments.

The prices and profits secured for and by the sale of all kinds of instruments, sheet music, and musical adjuncts, and the general principles of business have to be diligently acquired during this period. To excel as a tuner it is not necessary to be what is known as musical. Some of the best tuners are not pianists. There is no greater mistake than to imagine that the child with a good "ear for music" will make a successful tuner. An apprentice who is ambitious, nevertheless, will always learn sufficient of the art to enable him to play with facility arpeggios and chords so as to "try" the tone of any instrument.

Opening a Shop. Before deciding to start in the music business, it is very advisable to have a tuning connection as a basis. This is an important point, for experience has proved that man cannot live by music selling alone. Practical men who have gone through the mill know that the beginner should have a connection of at least 300 tunings per annum, and one-third of that number should be regular contract tunings. The usual charge for tuning a piano is 3s. 6d., and five pianos per day is an average day's work.

Although, in the music trade, connection is of greater value than mere advertisement, the latter should not be altogether neglected. One prominent music-dealer whom we have in mind advertised in a manner which gave the maximum result at a minimum cost. All he inserted in the local newspaper was, the first week, "Wanted, 1,000 pianos to tune." Then followed his name and address. Next week the wording was changed to "Wanted, 995 pianos to tune." The figures gradually diminished in this way, and the impression given was that the newcomer had succeeded in getting considerable business.

The Window. One of the cheapest advertisements for the music-dealer is to have his shop-front dressed as attractively as possible. In quiet country towns the magnetic qualities of a well-arranged window are much undervalued. It is a mistake to show the same goods continually. The windows should be kept scrupulously clean and not overcrowded. Effective displays need not entail expense. The most useful class of passers-by can be attracted by photographs of musical celebrities. For violins or brass instruments, a plush curtain forms a good background. Musical accessories, such as gramophones, metronomes, and glass insulators for the piano, can be grouped artistically. Frontispieces of new music are supplied by publishers for window display so as not to soil the music sold. But such title-pages should be always up to date. It is seldom that a beginner in the music trade has room to show pianos in his window. Should he be fortunate in this respect, care should be taken to have a blind ready to be lowered so as to secure temporary privacy when the instrument is tried.

Advertising Materials. The retailer should take full advantage of all help in advertising he can get from the makers of instruments he particularly represents. Some firms of enterprise are generous in this respect by (1) supplying well-framed and artistic showcards; (2) defraying the cost of decorating the window with enamelled letters and coats of arms illustrative of Royal appointments they hold—but in this case there must not be too much display of lettering on the front of the shop; (3) supplying music wrappers with appropriate advertisements; (4) and various stationery, such as letter paper and bill-heads bearing the dealer's address as well as an advertisement of the particular agency. Intelligent use of all such matter effects not only a considerable saving annually for the beginner, but stimulates business.

The Shop and Fittings. The foundation for the stock required in a music shop is often laid by the wide-awake young tuner while living at home. In the course of his vocation he has the opportunity to acquire cheaply second-hand pianos from customers who wish, for a variety of reasons, to dispose of them. In the course of a year or two he may

thus become the owner of several pianos, which he can keep in his private house until he finds it desirable to start a shop. The neighbourhood should be carefully selected, and should be as near as possible to the centre of the district where his tuning connection lies. The shop must of necessity be fairly good, well decorated and attractive. The fittings required are merely the usual counter, one or two glass cases, and lettered cardboard portfolios for music, all of which should cost not more than £10.

Stock. Owing to unchecked piracy in sheet music, there is at present no profit in it in Great Britain. Yet it is useful in keeping together a connection, or for attracting fresh customers. The typical music-shop is stocked with medium-priced and cheap pianos, American organs, self-players and phonographs, violins, mandolines, and other stringed instruments, military wind instruments, besides the "cheap lines," such as melodeons, whistles, mouth-organs, fiddle-strings, and various accessories. There is no need, at first, to tie up capital by keeping all such goods in stock. Pianos, and, in fact, nearly all musical instruments, may be obtained from the wholesale houses or factories on sale or return. They seldom need to be paid for until actually sold. Of course, if the beginner has a capital of £100 or £200 to expend, it is advisable to pay for as much of his stock as he can, so that he may be independent of trade creditors. With a few second-hand pianos acquired before starting, the beginner has already a show. He may then order half a dozen new pianos of various prices, and two American organs on approval. Then he can order, in the same way, or paying cash for the "small goods," three or four violins and three or four mandolines, and a judicious selection of accordeons, concertinas, autoharps, flageolets, whistles, mouth organs, jaws harps, music desks, fiddle and mandoline strings and fittings. A sum of £20 should suffice to make a good display and give a varied stock of these goods. Another £20 would be expended on sheet music, carefully selected and varied to suit all tastes. The selection or particular kind of stock necessary can be gauged only by carefully anticipating the needs of the neighbourhood, and it is here that the judgment and foresight of the beginner must be intelligently exercised. The large houses issue well-illustrated and comprehensive catalogues showing exactly every detail of articles wanted. The scope in small merchandise should not be overlooked by a beginner, as it is often relatively more profitable than the high-class trade.

Sole Agencies. To prevent underselling, manufacturers of standing, with but few exceptions, nowadays appoint a sole agent for each district or town. He has the right to arrange sub-agencies. But there is little profit derivable from a secondary appointment. The beginner will have no difficulty in ascertaining the names of the sole agencies held by established rivals in his locality. There are so many makers of repute that it should be easy to add another name to the list. A glance at the advertisements in the "Music Trades Review" or the "Musical Opinion" will enable the new-comer to approach those houses most likely to be useful to him. It is desirable to acquire the sole right to sell, within his town and the area covered by his tuning connection, one high-class make of piano and one medium class. At the annual Music Trades' Exhibition, if he has an opportunity of visiting London, he will be able to arrange for a cheap line and be sure of getting value for his money. The point is to see that such instruments stand in tune. Touch and tone-quality are secondary considerations, although they rank first with high-class makes. On the choice of the cheap line will most likely depend the success or failure of the new business. To every expensive instrument sold, probably a dozen cheap pianos will be disposed of. As the price is cut as finely as possible, and such instruments may be obtained wholesale from £10 apiece, the dealer is expected to pay promptly for them.

Hire System. When instruments are sold retail on the instalment plan, the profit on them furnishes the dealer's main source of income. But if this capital be small, the rock on which the practical man usually comes to grief is selling too many instruments on the hire system. Sometimes, even in cheap lines, manufacturers, eager to do trade, hold out the inducement of extended credit, and accept bills. When such bills become due, it is difficult to renew them. To give acceptance for goods received is always dangerous. Unable to find the necessary money, owing to the pianos received having been sent out on the hire-purchase system, the dealer is at the mercy of his wholesale "friends." He is fortunate if they take over his business, retaining him as manager. In that case, he will get a small salary and a commission on sales, so that, however hard he may work, a third party, unknown to his neighbourhood, pockets the harvest which should otherwise have been his. Many prosperous music-dealers owe their financial success to observance of the rule never to sign a bill.

Making a Connection. As regards the medium and high-class makes, these give the new business its reputation and furnish the connection with its best customers. Whenever an instrument of 50 guineas or upwards is sold, the dealer will have little trouble in arranging to tune the instrument periodically by yearly contract. According to the distance, so the price for four quarterly visits ranges from 12s. to 42s. per annum, a reduction being made for a second piano in the same house; and the tuner, after he has done his work, gets the contract-card signed, as a proof that the instrument has been duly attended. This is valuable to refer to when disputes arise after Christmas, before bills are paid. The new-comer will find that two sole agencies are sufficient for him. He should concentrate his energies on selling those instruments, but, before doing so, should be careful that the agreement he enters into with makers is so worded that, directly a demand is

created, the agency may not be taken away from him and put into other hands.

Commissions. It is in the sale of the higher class instruments that the question of commission arises. The music teacher, who has been the means of bringing an order for a piano to the dealer, naturally expects to be reimbursed for the time and trouble he has taken in the matter. But since the London Co-operative Stores, by giving wholesale orders, have been able to buy in bulk at dealers' prices, and have sold musical instruments to the public for cash, on terms formerly reserved for members of the musical profession, profits on cash transactions have greatly diminished. As the amateur purchaser receives stores prices, the margin left is nominal. Yet the intermediary is not likely to go out of his way to influence business if he does not receive back his expenses. What the Law, in recent enactments regarding secret commissions, stipulates is that an intermediary may act either on behalf of the seller or on behalf of the buyer, but he cannot represent both parties. Obviously, the music teacher, when he chooses a piano, and stands sponsor for it, endeavours to select the best instrument he can to help on the studies of his pupil. Therefore, as he is acting on behalf of the purchaser rather than the seller, it is becoming the rule of the professor to tell the parents the professional price, and add to it a reasonable fee for his services in that matter. Under such circumstances, no subsequent claim is made on the dealer.

Three Years' Agreement. Before supplying any musical instrument on the system of hire-purchase extending over one, two, or three years, the dealer should be careful to get a legal form signed and witnessed. It should bear a sixpenny stamp, fully describing the piano or organ supplied, and state the amount of the instalments and the dates when they become due. But the main object of the document is to make clear that until the instrument is paid for it remains the property of the dealer, and cannot be distrained for rent by a landlord, and that, in the event of its being destroyed by fire, the hirer agrees to continue to repay its value. In the event of the instalments falling into arrears, the owner also has the right to recover the instrument. Legally-worded forms are obtainable from the office of the "Music Trades Review." In exceptional cases, dealers have been unduly hard in resuming possession of a piano when almost all the instalments have been met. Sharp practice of that kind is, however, rare. It does not pay. What does pay is to hire out instruments on this system to customers whose instalments are received punctually, so that the dealer can not only meet his obligations to the manufacturer, but give the latter fresh orders. Care, therefore, should be exercised, in the first instance, to insure that the customer is honest, and a couple of references should be required.

Exchanges. Naturally, the first endeavour of the music dealer must be not only to supply what is wanted, but to make each transaction yield a profit. This is a difficult matter when orders for new instruments involve taking back old ones. People attached to old pianos fail to understand that modern improvements have rendered them out of date and commercially worthless. The outside may be "as good as new," and the original cost £150, but the twenty-year old grand is probably not worth £5. Nevertheless, the dealer may be obliged to offer £10, and his only way to dispose of it will probably be to get a traveller to take it off his hands, at the best price possible, conditionally on his giving the latter an order.

Ordering Music. Travellers' terms for music are more tempting than those offered by the publisher direct. The latter, when he brings out a new song or piano piece which he believes will become popular, speculates by printing a considerable number, and offers exceptionally liberal terms through his traveller to induce the dealer to share the risk with him. But the beginner cannot take risks. His music shelves, bearing the words "Songs," "Dance Music," "Piano Solos," "Piano Duets," etc., are mostly often dummies. It would not pay him to keep in stock the entire repertoire of the average professional or amateur musician. Instead, he orders single pieces of music by post direct from London through some friendly publisher who acts as collector for him. Some dealers make up such a list of music wanted twice a week on order sheets. In any case, a music-dealer should never depute an underling, however honest he or she may be, to give orders to travellers. A case occurred a few years since where a lady assistant was entrusted to order sheet music from samples. Instead of distributing such orders impartially to the different representatives who called, she put all her eggs gradually into one basket. The result was that when, at the end of the year, the proprietor came to take stock, he found his shelves loaded with ephemeral songs and dance music bearing the same imprint and worth the price of wastepaper. A golden rule is always to have the hands clean when showing sheet music. Once soiled, it becomes unsaleable. If possible, it should be put away into its case, if not wanted, before the customer leaves the shop. If there is small profit on sheet music, a better investment is to be found in albums of standard songs, pianoforte sonatas and oratorios. These do not spoil by keeping, nor get out of date like comic songs, ballads, and dance music. Some houses have an ingenious plan of furnishing entire libraries of classical music, indispensable to teachers, on favourable terms, provided that such stock is insured against fire or other damage, and the music-seller immediately orders a fresh piece to supply any piece sold.

Looking after the Shop. Better have no shop at all than not look after it properly. To many a beginner in the music trade, how to be in two places at once is a troublesome problem. His main source of income may depend, at first, on his tuning connection. That cannot be neglected. Prospective purchasers have to be waited upon at their residences with catalogues, etc. During such visits, a customer, who should receive special attention, may call at the shop.

It is here that the intelligent co-operation of a sister or wife has often been the making of a young man. Ladies have more patience with callers whose visits are unprofitable. It is unnecessary to have served a long tuning apprenticeship to be able to waste half a day exchanging sheet music or selling fiddle strings. Yet this has to be done. The young dealer should arrange his work so as to be in charge of the shop on such days which are busiest in the week. In country towns, this is generally when market is held and people make their purchases for the ensuing week. It is suicidal, however, for the beginner to neglect his tuning connection for the sake of the shop. If he is not in the happy position of having a wife or a sister to look after the place in his absence, he should engage an alert lady assistant at a cost of 15s. to £1 a week. Some tuners teach piano playing, and it may possibly pay to engage a lady teacher to play and teach in the shop, looking after the retail business in the meanwhile. The fee usually paid to a professional in such a case would be £1 a week with a commission on the teaching.

Repairs. The practical tuner, on his rounds, frequently has to attend to minor repairs. A keyboard instrument, unlike a violin—although that often requires seeing to—has much mechanism which wears out after a certain time. To repair a piano thoroughly, the shop must be provided with an apartment containing a bench, a hammer-covering machine, and other appliances. To fetch the instruments, a van will have to be hired, or, if that is not obtainable, a cart, should it have no springs, must be lined with straw. The repairs will probably occupy two months, and another instrument has to be supplied meanwhile, its use being included in the estimate given. For re-covering hammers, the usual charge is from £3 to £5, while a thorough repair, according to the work necessary, may be from £10 to £30. Where the workshop is not fully equipped, it is best for the dealer to send the number and other particulars to the maker, get an estimate, and then forward the instrument to headquarters. It is advisable at first to send as many of the small repairs as possible to a factory, for such work must be completed without delay, and the tuner's time can be better employed.

Taking Stock. The practice of shutting up during the afternoon on the now customary "Early Closing day" gives the beginner a weekly opportunty to make up his books, attend to repairs and other matters of importance without being interrupted by visitors. A man who has been trained as a practical tuner and not as a clerk often finds the clerical work irksome at first, but if he does not master the rudiments of bookkeeping he cannot hope to be successful financially. A good check on each day's takings is an automatic cash register. All items should be entered in a day book and transferred into a ledger. A diary, in which is recorded the dates of tuning visits due, should always be kept up, and customers informed by postcard before each visit. But a very important matter is not to neglect taking stock. This should be done once a month, and most carefully at the end of the year. It may involve considerable work to go through a quantity of sheet music and musical accessories which have accumulated. It is better to sacrifice profit and get rid of them, because a "sale" may attract new customers, and space is always of value. The main point is that the dealer should balance up his books periodically so that he may know how he stands financially, and reduce expenses in certain ways if he finds his liabilities increase unduly.

Aids to Business. The tuner who is also a good musician may perhaps increase his success in the neighbourhood by organising at-homes, concerts, and so forth, and by playing in private houses. The usual fee for such service is from 10s. 6d. to £1 1s. per night, but it is fatiguing work, and ruinous to health if kept up for any length of time. Although a matter of £20 to £30 a year extra may be made in this manner, and it may be helpful as an advertisement in the district, it should be discontinued as soon as possible.

Hiring out pianos to concert halls and to parties is another way of making an additional income, and an able man is always ready to supply orchestras, etc., for evening parties, all of which should bring profit in the way of commissions. But these things are subsidiary to tuning, which should be sedulously nurtured.

The Question of Profits. The average percentage of profit on the sale of music is a small one. It must not be forgotten that the articles sold are, in a sense, luxuries, unlike the necessities of life supplied by a grocer, butcher, or similar shopkeeper. The average of profit on the direct turnover should actually realise from 30 per cent. to 40 per cent. Sheet music of the cheaper sort bears a big profit usually —a sixpenny song will cost less than threepence —but the higher-priced music, that marked 4s., but actually selling at 1s. 4d., costs about 1s. 2d. wholesale, and sometimes more. There is therefore no profit in selling the dearer music under present conditions; but there is a big future for cheap music, provided the cutting of price is effectually prevented. It is not only that the depredations of the "music pirates" are to be deplored, but that the suicidal undercutting of prices between one dealer and another in the trade prevents a living profit being obtained for everyone. The music trade has its possibilities for the intelligent dealer, and particularly for the careful, efficient and well-trained tuner. There are so many imperfectly-trained and incompetent "tuners" at work that the energies of competent and careful men, if properly directed, reap a rich reward.

Continued

Group 12
MECHANICAL ENGINEERING
27

Continued from page 3694

ENGINEERS' COPPERSMITHING

Brazing Materials and Practice. Copper Pipes and Spheres. Templets, Bends, Tees, Branches, Joints, and Flanges

By JOSEPH G. HORNER

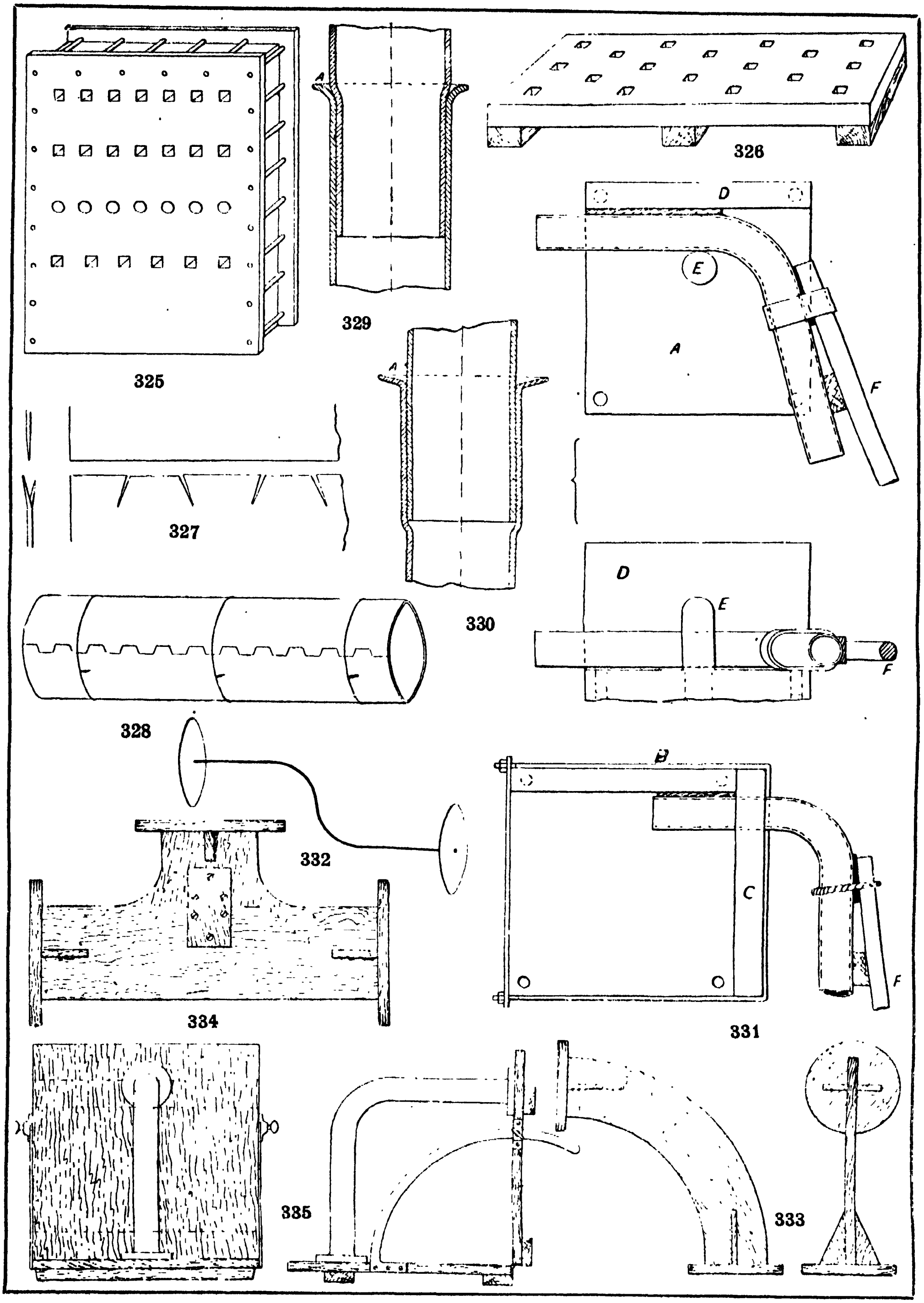
ENGINEERS' coppersmithing is a special branch of work done by men who have usually been trained in engineers' works, and have therefore had no experience as braziers or artisans in cooking utensils. It includes the work of the marine and locomotive shops, of brewing utensils, sugar-pans, and some pump parts. The principal kinds of articles treated are pipes, bends, tees, with their flanges or other fittings, steam-dome coverings, safety-valve covers, coppers, pans, etc. The shops are larger than those of the ordinary brazier's, and the appliances are larger, and some are of a special character. The work of the engineers' coppersmith has been invaded in one direction by the manufacture of seamless pipes and tubes, and by those that are produced electrolytically—developments due to the risks of using brazed pipes for the high steam pressures now common. Much bending of pipes is also done by means of rollers instead of by hand.

The Shop. The engineers' coppersmiths' shop is, as a rule, larger than that of the ordinary brazier's, because the mass of work done is larger. It is also more lofty, so as to permit of the handling of pipes, which form the largest section of the work done. The pipes and other articles are hung from a hook on one end of a chain, which runs over a pulley suspended from another pulley, or *traveller*, that runs along a rail below the roof. There are hooks in the walls, to which the free end of the chain is attached when work is slung over the forge fires for brazing. The shop also contains a mandrel-block [**325**], with holes to receive numerous mandrels for bending pipes and other articles on; also a bending-block [**331**], a floor-block [**326**], with holes for various stakes; forges; vice-benches with drawers; pits, 5ft. or 6 ft. deep to receive pipes, and having a blast-pipe for brazing; fires for melting resin and lead for pipe filling; trestles for carrying work upon, and some other common appliances; and a stock of tools, as stakes, hammers, cods; also bins for coke, boxes of spelter solder, borax, etc.

Pipe Work. Straight copper piping is now seldom made by bending and brazing, but the same methods are often employed in other work, and in odd sizes and shapes of pipe. Bending is done round mandrels, and the joints are made either by thinning or cramping [**327**]. Thinning alone is suitable for heavy material, but cramping is nearly invariably necessary with the lighter, because it strengthens the joint materially. Notches are cut along one edge at a bevel, at intervals of from about 1 in. to 3 in., dependent on the size of the work, and the metal is bent to right and left alternately. The other edge is thinned and inserted between the cramp, as shown to the left in **327**, so that alternate cramps come on opposite faces of the thinned edge. The pipe is bound with wire [**328**], and the joint closed with a mallet or hammer round a mandrel. It is then *chattered*, or *jarred*, to cause the parts to open slightly, so as to permit of the spelter solder flowing between the adjacent overlapping portions.

Brazing Materials. The methods of brazing are all essentially alike in principle, but details differ with the character of the work. Sometimes the borax and spelter are charged separately, but it is better to mix them in equal proportions with water, and preferably a day or two before use. The mixture must be laid evenly along the joint, and the pipe or other article placed in a clear coke fire, of which the temperature is regulated until the borax fuses and *drops*, and the spelter begins to melt and run, as indicated by the blue fumes of the zinc. It may be necessary to add more borax finely powdered, and the pipe may be tapped lightly to assist the running of the solder in the joint. Spelter solders are composed of various alloys of copper and zinc. The strongest, for copper, comprises 3 of copper and 1 of zinc. A weaker is 16 of copper to 12 of zinc. Another is 8 parts of brass tubes to 1 of zinc, and for brazing brass, 1 of copper to 1 of zinc. Joints to be brazed are cleaned by covering the parts with a strong brine made of salt and water, then heating to a cherry red, and quenching in clear water—which also has the effect of annealing the copper—followed by scouring with clean water and sand applied with a wad of tow.

Brazing Practice. A piece of pipe must be laid horizontally for a seam joint, and if the joint be long, runners should be provided on stands outside the forge to allow of ready and easy movement of the pipe through the fire. If joints have to be made in pipe lengths, they must be suspended vertically, and the joints are those suitable for pipe, being either flush [**329**] or socketed [**330**]. The first retains the external diameter, but reduces the bore; the second retains the bore, but enlarges the external diameter. A flange, A, is laid off on the socketed portion to retain the solder and to prevent it from running away outside the pipe. This is filed off subsequently. Such joints are made either by soldering or by hard brazing. If the former, both internal and external pipes must be tinned. Heat is applied to the pipes for soldering and brazing by means of fire-pots. In small pipes sufficient heat may be obtained by a pair of red-hot tongs. Large pipes may be soft-soldered by hanging a pot of burning charcoal inside. But in other cases a fire-pot encircles the pipe, and the latter is held with screw clamps in suspension within the pot, the height being



TOOLS AND PROCESSES IN ENGINEERS' COPPERSMITHING

325. Mandrel-block **326.** Floor-block **327.** Edges thinned and notched **328.** Cramped pipe bound with wire **329.** Flush joint **330.** Socketed joint **331.** Bending-block with attachments **332-334.** Pipe templets **335.** Templet-board

adjusted with one of the sling chains, to which a weight is added on the slack side to counterbalance the weight of the pipe, or the chain may be fastened to the wall. The fire-box rests upon a clamp which is made to grip the pipe. It is filled with charcoal and coke broken small, and is fitted with a blast-pipe and holes arranged round an annular ring, much resembling the arrangement in the annular wind-chest of a cupola furnace. Care must be taken that the solder does not run away at the bottom of the joint. Lampblack and gold size may be rubbed round the bottom, or moist clay. Or, if the joint be tinned, the tinning must stop short of the end. As soon as the spelter has run, it is skimmed off flush with the top of the socket, and salt is strewn on to kill the borax, which would otherwise leave a hard surface to interfere with subsequent filing.

Pipe Bending. There is a good deal of pipe bending done. In the absence of special machines, simple leverage is the method adopted, and a *bending-block* [331, A] is fixed in the floor of the shop for the purpose. It is of cast iron, about 14 in. or 15 in. square, and pipes up to 5 in. can be bent on it by hand. It is shouldered, or rebated, round the top to receive an iron strap, B, by which a *lead piece*, C, is secured on the block. This lead piece has a hole to take the pipe to be bent without bruising it. The leverage is taken against a back plate, D, that fits by pins edgewise on the bending block. When the lead piece is not used, a pin, E, is dropped into a hole on the top of the block, and the pull taken between this and the back plate. The pipe is pulled round by a lever, F, secured thereto with a loop of rope or a copper band. Bruising is prevented by packings of lead or soft wood at all localities where pressure is made against the pipe.

Two preliminaries are essential to bending pipes and tubes—filling the pipe with lead or resin to prevent puckering, and annealing the part to be bent, the remainder to be left hard. For small curves, soft lead is better; for long ones, resin. The straight part is not filled, but the progress of the lead or resin is arrested where required by rolling up a hard ball of paper and thrusting it in. The lead or resin are melted out subsequently to the bending.

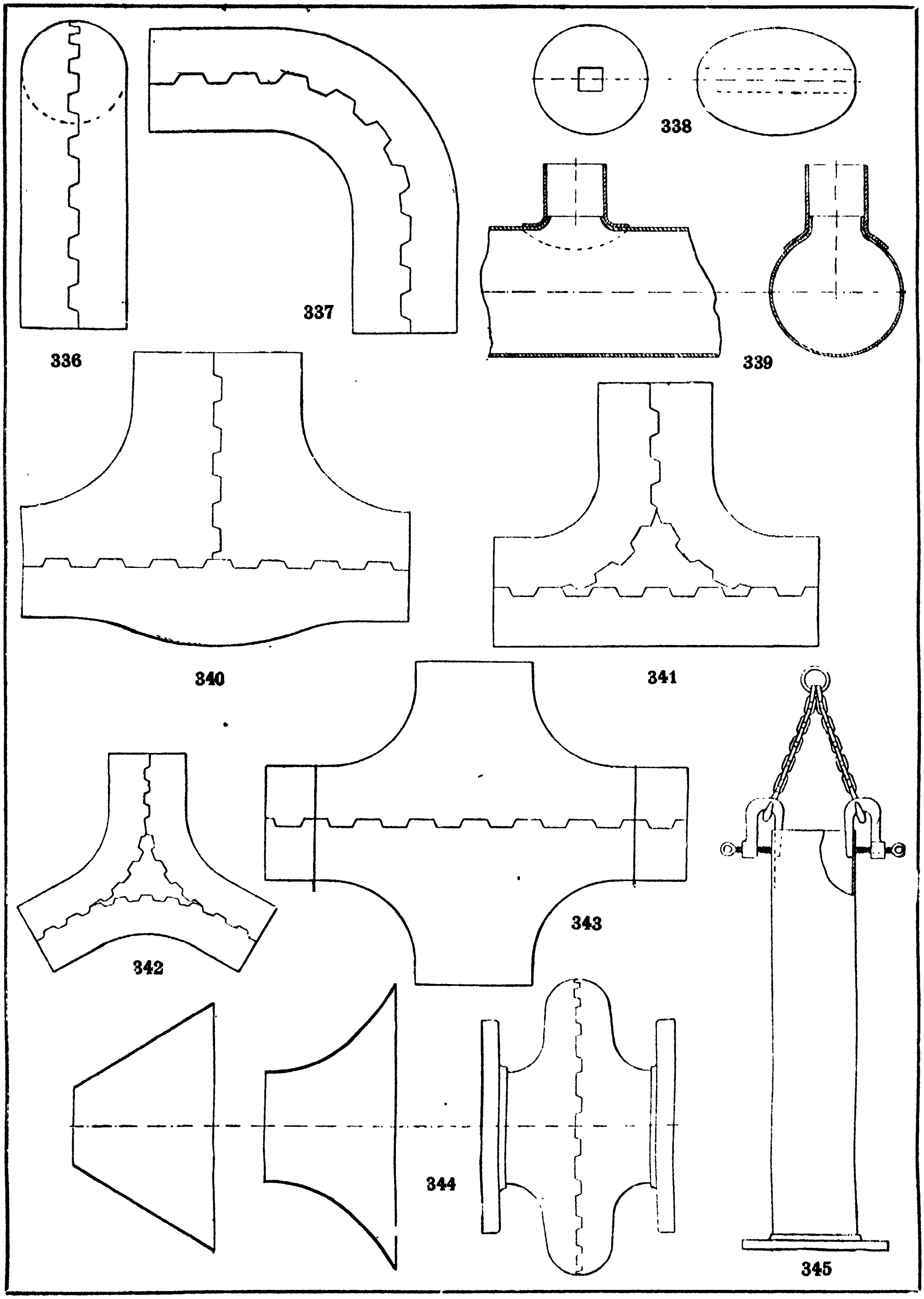
Templets. Pipes are generally tested during bending by templets of iron rod of from ¼ in. to ⅜ in. diameter in smaller and larger templets [332]. The rod must be sufficiently stiff to retain its shape while being handled. The curves correspond with the centre of the pipe being bent, and the templet is laid upon the pipe from time to time as the bending proceeds. Templets of wood [333 and 334] are frequently made by the pattern-makers or carpenters. The outlines of these correspond with the external edges of the pipe. They are of deal, about ¼ in. or ½ in. thick. If flanges are required, these are indicated by flanges nailed on the ends of the board and secured with brackets, as shown.

There is a different kind of templet, termed the *templet board* [335], which is not used to give the curve of the bends, but their lengths. Its purpose is to fix the exact positions which the flanges have to occupy in the marine engine or locomotive, so that they go into place without any tentative fitting. In repetitive work a model of the part in which the pipes have to fit is kept. Thus the steam pipes for locomotive smoke-boxes are fitted in a model box, and go into the engine only when the work is finished The templet board [335] comprises two boards, hinged so that they can be set to right or other angles, with wing or quadrant pieces, and clamped, and the faces of the flanges are fitted against them at the lengths required. They are most useful for repair work, since a broken pipe can be pieced up and repaired to correct lengths by first fixing the templet board correctly, and marking the positions of the flanges on the board.

Made Bends. The term *made bends* signifies bends that are not bent from straight pipe, but are made in halves from copper sheet, which is hollowed to the forms required in *hollowing blocks* and over *tee stakes*. The halves may be joined at the sides [336] or along the interior and exterior radii, *throat* and *back* [337]. This is more difficult work than mere bending of pipes, because the metal has to be upset on the shorter radii, and drawn on the larger, and wrinkles will form which will have to be worked out over the tee stake. The joints are made by cramping, and closing over a *cod* [338] on a mandrel standing out from the mandrel block. Allowances have to be made for the bending and puckering which takes place, and much practice is necessary to ensure good results. In manipulating large bends for brazing, the halves are pulled together with an encircling chain and bolt slung suitably over the fire, so that they can be readily manipulated without crushing the fire.

Tees and Branches. These are attached to pipes by soldering or brazing, though in some cases they are cut from the solid sheet. When fitted, the end next the pipe is bell-mouthed and flanged slightly, and the flange is fitted to the curve of the main pipe [339]. A hole is cut in the latter, smaller than that in the branch, to allow metal for turning outwards to enter the *flaring* portion of the branch. The burred edge is made to fit neatly within, and the flange on the outlet to fit the pipe body neatly. The joint is then ready for securing. If it be soft-soldered, the joint faces are now thinned; if to be brazed, the flange of the branch is coated with spelter solder. The spelter is strewn on the face and melted, and spread evenly over it. It is then placed on the pipe and secured with binding wire, and the pipe laid on the forge. Spelter and borax are strewn on flange and pipe adjacent, and the parts are heated up slowly at first, and more rapidly as the heat increases, until the spelter runs through the joint.

Made Tees. Large numbers of *tee-pieces*, or three-way [340 to 342], and *four-way*, or *cross-pieces* [343], are made from copper sheet, which is cut, cramped, and brazed. There are different ways of jointing adopted—in the plane common to the branches, in saddles or throats, or at right angles therewith, with gussets [341 and 342] or without gussets [340]. Large bends are better made with the joint in the throat and back (*saddle*



ENGINEERS' COPPERSMITH WORK

336 and **337.** Made bends **338.** Cod **339.** Branch fitting **340-342.** Tee-pieces **343.** Cross-piece **344.** Expansion joint **345.** Pipe suspended for brazing a flange on

and *back*) than in the other direction, though many are made in the latter way. Fig. **343** shows a tee piece, but the jointing may be done in alternative ways, as in bends.

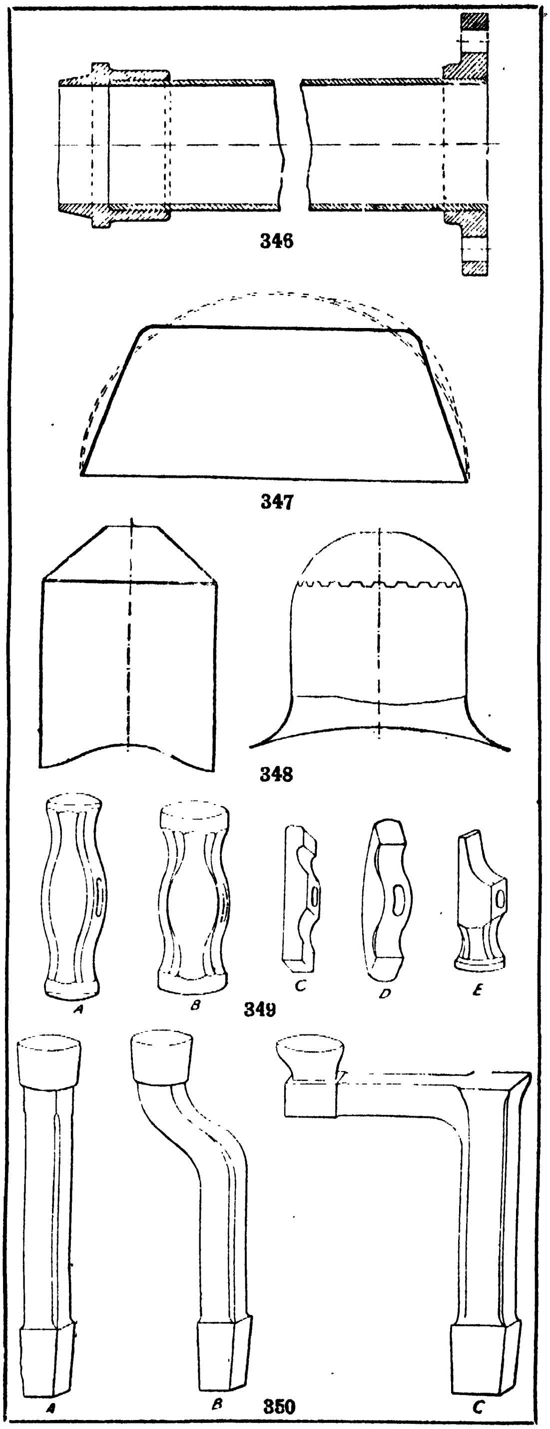
Expansion Joints. Expansion joints [**344**] are in frequent use, and are made by two conic frusta in the first place, with cramped seams, which, after being drawn out round the edges by hammering, are cramped in the central plane of the expansion piece and brazed. The brazing may be done from inside or outside. The figures to the left show one coned piece, and the same when drawn out or bell-mouthed,

Flanges. Large numbers of flanges are brazed on copper pipes. The pipes are slung vertically with flanges lowermost [**345**]. A little clearance is allowed for the spelter to run in. The hole is slightly tapered, and, properly, the end of the pipe should be. The flange bore is countersunk on the face side, and the pipe very slightly opened out [see also **346**]. The countersink is filled with fine soft clay, to prevent the spelter from running away. Sometimes the heat has to be prevented from going up the pipe by filling it up with a plug of wood or cotton-waste, or, in large pipes, with an iron disc luted with fine clay.

Fig. **346** shows the internal steam-pipe of a locomotive that runs from the tube plate to the regulator. It has a flange brazed at one end, as in **345**, and a cone at the other. Both are bored to fit the pipe, and brazed when in a vertical position. The countersunk or burring over at the flange end will be noticed, and the recess in the top of the cone piece to receive the solder. The cone is covered with fireclay and plumbago during the brazing.

All flanges to braze to copper pipe must be of pure copper, or of *brazing metal*, 98 of copper to 2 of tin; or a mixture of 1 lb. of old copper to 1 lb. of brass tubes. If flanges are supplied of ordinary gunmetal they will melt before the spelter fuses. In such a case the melting point of the spelter must be lowered with slight additions of zinc.

Hollow Spheres. Hollow spheres [**347**] are produced by hollowing in halves, which are brazed together. The diameter of the disc to form, when raised, the half of a sphere is obtained by the well-known property of the sphere—namely, that its surface is equal to that of its circumscribed cylinder, or equal to that of four discs of the same diameter as that of the sphere. So that the surface of each disc would be equal in area to that of two discs of the same diameter as the sphere, to which allowance must be added for seams. Hollow spheres are made in solid halves, or in halves as a frustum of a cone, and a bottom or *pan* cramped and brazed in; the latter being sometimes more convenient than having to find metal for large discs. If a disc



COPPERSMITH WORK AND TOOLS

346. Steam-pipe with flange and cone **347.** Hollowing a hemisphere **348.** Steam-dome covering **349.** Hammers **350.** Stakes

351. COPPERSMITHS' SHOP (Isaac Storey & Sons, Limited, Manchester)

be used, a circle is struck from the centre having a diameter equal to half the diameter of the disc to serve as a guide for *wrinkling* into cup or pan form first. Next, the wrinkles are worked out with the hammer over a stake and smoothed, which is the stage in **347**. Annealing follows, and the wrinkling is repeated in courses. Then the *lag*, or angle between the sides and bottom, is hammered out on a stake, and the curve of the side and bottom produced. After annealing, cleaning, and planishing, the halves are ready to go together. If the halves are produced each by cramping a bottom in a conic frustum, the conic frustum is formed by a cramped and brazed joint, and the bottom cramped and brazed in. Afterwards the spherical form is imparted by hammering.

Dome Coverings. Dome coverings [**348**] are made in sheet brass in two pieces, a cylinder and a crown, brazed with cramped joints. The diagram shows the operations clearly. The foot is worked round by hammering, and the top or crown in a hollowing block, or at the mandrel block in courses, annealing being done between the courses. After smoothing, it is cramped and brazed, being slung on the traveller chain. The brazing is done in detail, one cramp at a time. The cover shown has a hole in the top. When this is not the case the cap piece may be cupped out in the solid, or it may be made with a hole as shown, and a crown piece cramped on and brazed.

Fig. **349** shows a few only of the principal hammers which have been referred to in this article. They are the *hollowing* (A), the *planishing* (B), the *razing* (C), the *creasing* (D), and the *riveting* (E). Fig. **350** shows some of the stakes, A and B being bullet stakes, straight and cranked, C a horse with stake inserted in the end, the angling of the horse being done to enable awkward work to be tackled.

Fig. **351** illustrates the coppersmithing shop of Messrs. Isaac Storey & Sons, Ltd., at Manchester. Instead of the traveller chains, it is fitted with swinging jib cranes and an overhead traveller. Two pans are seen in the foreground, one to the right cramped ready for brazing, and one to the left already brazed. The brazing hearth stands just behind.

Behind the hearth the workman has a bend pipe suspended over a mandrel sticking out from the mandrel block. At the extreme left-hand lower corner a hemispherical piece is having its wrinkles taken out by planishing. At the extreme right lower corner a condenser is being fitted up. Various templets will be seen hanging on the right-hand wall.

Continued

FOOD FOR DAIRY STOCK

Being a Brief Enumeration of the Various Grasses, Forage and Leguminous Crops, and Concentrated Dry Foods suitable for Dairy Cattle

By Professor JAMES LONG

Value of the Grasses. In supplying food to the cow it is more advantageous, because more economical, to provide a mixed ration, where the animals are stall-fed, than food of one particular kind. Thus, during the grazing season a cow obtains upon the pastures, unless they be very inferior, a mixture of grasses, clovers, and other herbage which not only belong to different natural orders but which are differently composed. Grass is the most important food of the cow, and it is important in proportion to its quality and variety. Grass, however, is a term applied to the herbage growing in pastures and meadows, and is, therefore, as already observed, a mixture of many plants. Both pasture and meadow under careful cultivation for hay provide a minimum number of inferior grasses and weeds and a maximum number of superior grasses and plants of the clover tribe, which, flowering at different periods, provide a succession of growths, and maintain, therefore, a sufficient bite for grazing stock. Although cows may graze during a large part of the year, the herbage is more or less abundant only between May and October, and unless the land be overstocked it is during this period that they improve in condition and yield the largest quantity of milk. Mature grass, partly owing to the fact that it contains more fibre than young grass, is of less value as a food When young and succulent it is more nourishing and digestible, and when cut and dried it produces the best hay. There is no greater mistake than that usually made by those who leave grass crops intended for hay until they have passed maturity in the hope of obtaining a larger crop. The weight of hay gained may be greater, but quality is sacrificed The value of grass, like hay, depends largely upon its richness in digestible albuminoids, and the proportion of these materials present in a sample is greater when the grass is young.

The Foods that Should Supplement Grass. Where soil is in poor condition the grasses are not only inferior in quality but in variety, nor do they grow so luxuriantly. The result is that it becomes necessary to supply the cows either with green forage crops to supplement grass or with meal or cake in order to make up for its deficiency in nutritive matter, and especially in the albuminoids. Where grass is luxuriant but deficient in clover herbage, an addition of a nitrogenous cake or meal is desirable [see page 2704], the clovers being the richest in nitrogenous matter among the cultivated pasture plants. The rainfall is also an important factor, and it is for this reason that corn-growing is common in the Eastern and grass in the Western counties. The systematic supply of manure, or the feeding of the cows upon cake, is followed by an increase in the clover herbage, especially in white clover, and where a pasture or meadow is well stocked with clover and perennial ryegrass—the latter a rich and important plant—its feeding value is considerable.

Varieties of Grasses. The farmer should make himself acquainted not only with the clovers and trefoils but with the superior and inferior grasses [see pages 872 and 940]. Among the former are foxtail, cocksfoot, perennial ryegrass, catstail or timothy, hard fescue, tall fescue, meadow fescue, and smooth-stalked meadow grass; while among the latter are red fescue, sheep's fescue, the brome grasses, fiorn or creeping bent, Yorkshire fog, and tall oatgrass. There are, however, many others of doubtful quality. Among the weeds, yarrow or milfoil, plantain, and burnet are sometimes classed, but these and other plants which belong to neither the grass nor the clover families and which are commonly found in pastures and meadows are in many cases relished by stock. The provision of liquid manure, which sometimes enables the scythe to cut four crops of grass in a season, as employed in Scotland and Switzerland with great advantage, very largely increases the weight of the crop; and this remark applies equally to the employment of farm sewage. This manure, chiefly the urine of the cattle, is distributed over the land immediately after the cut grass has been removed. It may be remarked that its influence is not only owing to its marked superiority over solid manure but to its liquid character, gratifying to plants at a time in which the soil is dry. The extra labour involved is more than repaid by the largely increased crop.

Feeding in Hot Weather. Cows are frequently fed on ryegrass manured with liquid, or upon forage crops of other varieties, lucerne, vetches, clover, sainfoin, maize, green rye, and cabbage, which are cut, and carried either to a dry pasture or to the stall in which they are tethered during the hot days of summer. Extra labour is involved in the cutting and carting; but, on the other hand, labour is saved in the better condition of the ditches and hedges, in the driving of the cows to and from the fields, in the prevention of their excited and roving habits owing to the heat and to flies, with the result that they do not break into the cornfields of neighbours, involving damage and unfriendliness. In the Channel Islands and in some parts of the Continent, especially in France and Denmark, cows are frequently tethered upon grass, a stake, to which a rope or chain is

attached, being driven into the ground, and a limited supply allotted to each animal.

Hay. In many parts of England hay forms the principal part of the winter ration. As we have seen, it varies in quality with the age and character of the grasses from which it is made. If the grasses were old before cutting, the stems may be chiefly composed of useless fibre, the nutritious portion of the plant having passed into the seed, which, where cutting is too long delayed, is often shed upon the ground. In such a case hay is of but little value. Inferior hay contains a much smaller quantity of feeding matter than good hay. It may, nevertheless, be utilised if the feeding matter which has been lost be added in the form of cake or meal. Where hay is employed as a leading food a cow may receive from 10lb. to 25 lb. daily in accordance with what is supplied in the ration in addition. First-rate hay is usually too valuable to employ with freedom for milk production, especially when prices are high and when other foods costing less will secure an equally good result. Good hay is the best balanced of all dry foods. Owing to its fragrance and sweetness it is agreeable to stock, and from this point of view cannot be replaced, but for the production of butter and cheese it is inferior to grass. Early cut grass, which contains more moisture, demands greater care in making and stacking.

Forage Crops. The forage crops are chiefly grown for the dairy herd on the arable farm, but the grass farmer is wise in planting a small area, though succulent food may be employed during the months of July and August, when the pastures are frequently bare. Forage crops, without exception, are less well-balanced than grass, and therefore less useful when supplied alone. Unless they be mixed, as where oats or rye are grown with vetches, they should be supplemented with cake or meal to prevent loss by waste. Foods like lucerne, vetches, and clover, which are exceptionally rich in albuminoids, should be supplemented by a dry food rich in carbohydrates, while foods like green maize, rye, and cabbage, should in their turn be supplemented with a rich albuminous food like cotton-seed meal, bean-meal or pea-meal [see Table, page 2704]. If there be no addition the excess of albuminoids in one food is not utilised, while the excess of the carbohydrates is similarly lost in another.

The remarks upon foods which follow supplement those already made on pages 2702-6 and 2904-9, and refer to the special feeding of milking cows.

Leguminous Crops. Among the leguminous crops which are most suitable are lucerne, sainfoin, vetches and the clovers. *Lucerne* [page 1197] should, however, be given with food rich in starch. *Sainfoin* yields 15 tons to 17 tons per acre, and is twice cut. Like lucerne, it makes superb hay, and is suitable for cows, especially when rice-meal or maize-meal are added. *Vetches* or *Tares* are only once cut, although, when cut early a small growth follows. The winter vetch seed mixed with oats or rye provides a more suitable food for cows, coming early in spring, when they may be followed by spring vetches which are good in late summer and autumn. Like all similar succulent forage plants, the vetch should be cut a day before using. If supplied to the cows quite fresh, it may cause hoven, or distention of the abdomen, which is sometimes followed by death. The *Clovers* [pages 940-1] include the broad red, crimson and white trifolium, incarnatum, alsike, and trefoil, which are the most suitable as cow foods. They should, however, to be perfectly suitable, be mixed with grasses or fed on the pastures, or, if in stalls, supplied in conjunction with meal rich in starch, as already shown. Cows may be tethered on either the red or alsike variety, after becoming accustomed to the process. Where clovers are grown with ryegrass or catstail they provide a better balanced food.

Various Forage. *Cabbage* is grown on many soils and to great weights per acre. By the aid of cabbage, forage crops and roots, cows may be fed through the entire year on natural succulent rations. *Kale*, a variety of the cabbage tribe, may be cut twice. *Rye* [page 874] is perhaps the earliest of all spring green crops. The average yield is from five to six tons per acre, but owing to its early harvest its value is out of proportion to its small yield. *Maize* [page 1198] is essentially carbonaceous. Owing to its sweetness it is relished by cows, and produces no waste.

Roots and Tubers. The plants supplying these foods are costly in cultivation, but they have a double value inasmuch as they enable a farmer to clean his land, which they occupy with advantage in his rotation.

The *Mangel* [page 942] is the most important, although, owing to climate, it is generally supplemented by the swede in North Britain. It is harvested in October, clamped, or pitted, and usually supplied to cows from January forwards, keeping until after midsummer, although, owing to chemical changes, its feeding value, like its weight, is diminished. Since certain varieties are much richer in nutritive matter than others, while other varieties are greater croppers, the grower should endeavour to fix upon the variety which returns him the greatest weight of digestible matter per acre. From 20 lb. to 50 lb. daily may be supplied to each cow. The yellow tankards and globes are preferable to the long reds.

Swedes and *Turnips* are commonly used for dairy stock. The approximate percentage of dry matter in sugar in the various bulbs referred to is shown by the following figures, the result of the work of the late Sir Joseph Gilbert.

Roots.	Dry matter per cent.	Sugar per cent.	
		In fresh roots.	In dry matter.
White turnips ..	8·0	3½ to 4½	44 to 56
Yellow turnips..	9·0	4 to 5	44 to 56
Swedes	11·0	6 to 7	55 to 64
Mangels	12·5	7½ to 8½	60 to 68

Swedes and turnips may be pulped, sliced, or cooked for mixing with the cow's ration of chaff, greens, and meal.

Kohl-rabi is but little used by the dairy farmer, although those who grow it for cows speak of it in high terms and in some cases prefer it to any similar food. Kohl-rabi keeps well throughout the winter, and communicates no ill flavour to the milk.

Probably owing to its sweetness, the *Carrot* is much relished by milking cows. Owing to the richness of the carrot in carbohydrates, it should be supplemented, when supplied in large quantities, by foods, such as cotton-cake, which are rich in albuminoids. The crop, when carefully stored, keeps well through the winter. The leaves may be fed with advantage.

The *Parsnip* [page 945] provides 12½ per cent. of digestible dry matter in its roots, 11½ per cent. in its leaves, of which in each case about 10 per cent. are carbohydrates and 1¼ per cent. albuminoids. It flourishes on a similar soil to the carrot, keeps well, but is not so much relished. The best field cropper is the Jersey hollow crown.

The *Potato* crop, when abundant and cheap, is frequently employed either cooked or raw.

Concentrated Dry Foods. These foods are chiefly the by-products of the milling of grain, of the processes of oil extraction from seeds, and of the manufacture of sugar, starch, and alcoholic drinks.

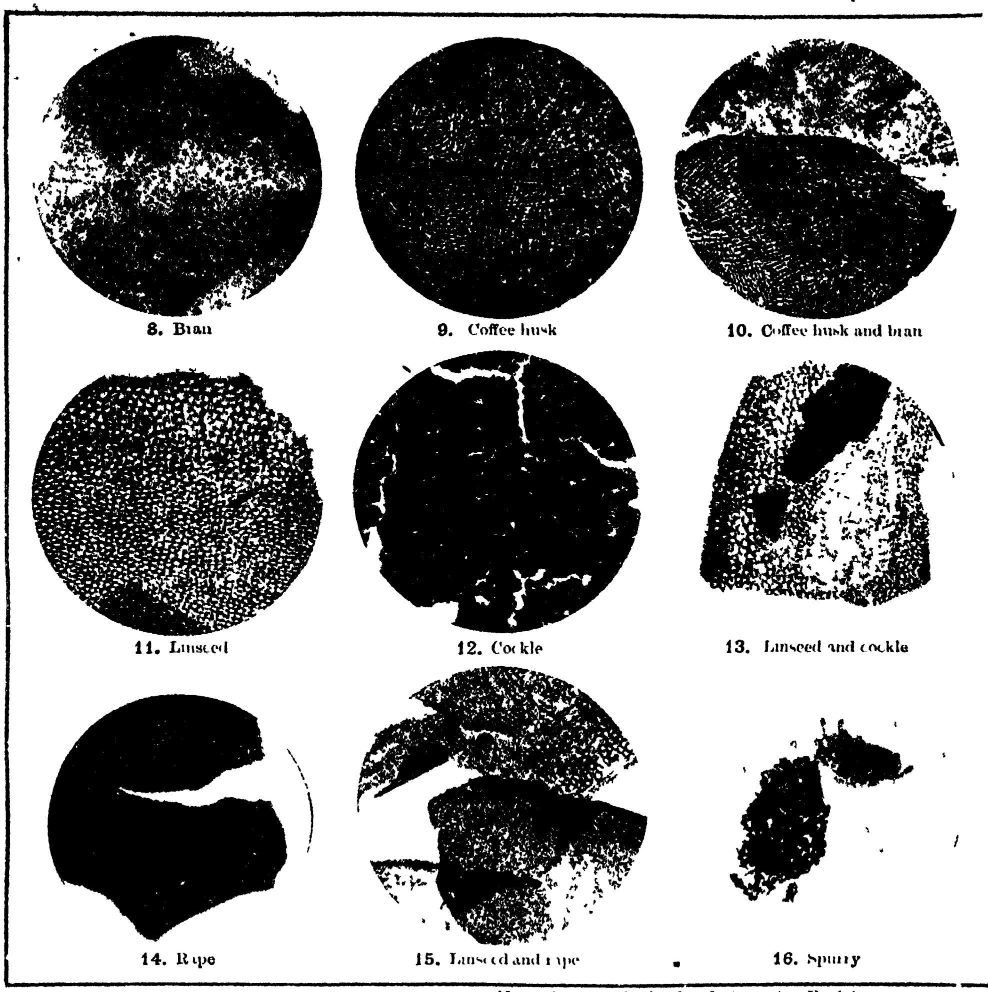
Linseed Cake [page 2907] is more useful for mixing with *cotton cake* than for employment alone in a ration. It should not be too hard, containing not less than 10 per cent. of oil, 28 per cent. of digestible carbohydrates, and 23 per cent. of digestible albuminoids. It is of high value in the rearing of young dairy stock. When broken it weighs 43 lb. to the bushel. The product of the cotton seed is used in three forms for cows—as meal, decorticated cake, and the common, or undecorticated, cake. The last-named is highly fibrous, and if less costly, is much less economical, as reference to the composition tables on page 2907 will show. The meal and the best cake are highly relished by cows, are of great value for milk and butter production, and are believed to make butter firmer than any other food.

Rape Cake possesses a disagreeable flavour, although it is very rich in feeding matter, and is consequently used in various patent foods. Owing to the small demand its price is low; but when used for cows patience must be exercised in inducing them to eat it readily. Another useful food, but little used in this country, is *Palmnut Cake*, which is readily eaten by cows. It is extremely rich in oil, and, when obtainable at £5 a ton, it is most economical. *Bean-meal* is highly nutritious, and weighs 50 lb. to the bushel. It is useful for employment with roots, cabbage, straw, inferior hay, rice or maize-meal. *Pea-meal* is richer than bean-meal, and may be similarly employed. English peas, however, like English beans, are usually too costly for cows; hence, imported pulse is employed. *Lentils* are frequently placed on the market, and if poor in oil, are rich in the other feeding constituents. Lentils weigh 63 lb. to the bushel. *Rice-meal* is extremely rich in starch and should be used on that basis alone. It should never be used without analysis. *Gluten Meal* is a residue in the manufacture of starch from maize. This is an American product of high value, when it is pure; but it is only in its experimental stage in this country. *Bran* [8] is a most valuable addition to the ration of the cow. Bran weighs 17 lb. to the bushel. *Sharps* or *coarse pollards*, like *middlings*, which are still finer, but richer in starch, are both useful foods when prices are low, and although less laxative, they are as rich and as sweet as bran. *Maize-meal*, which weighs 47 lb. to the bushel, is a highly concentrated and valuable food, largely used when the price is low. Compared with the oat, it contains 50 per cent. more feeding matter, weight for weight, when prices are identical. Maize-meal is especially valuable when cows are fed upon hay, herbage, or forage crops unusually rich in albuminoids. *Maize Germ Meal* is a comparatively new food, is rich in all the feeding constituents, and when pure and costing £4 to £4 10s. a ton, is a very useful addition to the ration of the cow; it is, however, frequently adulterated.

Oats [page 873], although a costly food, owing to its low weight, its price per bushel, and the proportion of husk or fibre, is one of the most valuable for milk production. A good oat, weighing 40 lb. to the bushel, and costing 20s. per quarter of eight bushels, provides 177 lb. of digestible feeding matter at a cost of about 11s. 6d. per 100 lb. A quarter of maize weighing 60 lb. to the bushel, and purchased at a similar price per quarter, produces 340 lb. of digestible feeding matter at a cost of about 5s. 9d. per 100 lb. Thus, in purchasing foods it is essential to consider not only the price per quarter or per 100 lb, but the actual cost of the feeding matter which each food contains [see page 2705]. Some allowance, however, may be made, as in this case, owing to the mechanical superiority and better balance of the oats as compared with maize.

Grains are obtained from distillers and brewers in a wet, and from merchants in a dry, or desiccated, form. They mix well with chaff and other foods. *Dried grains* may be used with confidence and success if the water be carefully added a day before they are to be used. They weigh 20 lb. per bushel. Brewers' grains are richer in phosphoric acid and lime than the barley from which they are produced. *Malt Culms, Germs*, or *Sprouts*, are the small dead radicles, or rootlets, of barley which has been malted. They are sweet, of agreeable flavour and odour, and well adapted for mixing with chaff and pulped roots.

The *straws* of cereals and pulse are of high value inasmuch as they provide the padding which is so essential in the feeding of an animal with such a capacious belly as the cow. The best straws are oat and pea, but wheat, bean, and vetch straw are sometimes used. All straws are preferably chaffed, or chopped, for mixing with rations. The chief feeding con-



8. Bran 9. Coffee husk 10. Coffee husk and bran

11. Linseed 12. Cockle 13. Linseed and cockle

14. Rape 15. Linseed and rape 16. Spurry

FOODS AND THEIR ADULTERATION (Microphotographs by Dr. J Augustus Voelcker)

stituents are the carbohydrates and the cellulose, of which about one-half are digestible in the cereals and slightly more in the pulses The pulse straws not only provide more feeding matter, but they are richer in albuminoids

Adulteration. In the course of these lessons we have often referred to the adulterations to which dry foods are subjected, and the analyses undertaken by specialists and others holding appointments under the various county councils and agricultural societies. In the detection of adulteration the microscope is of the greatest use, for it is frequently only by it that admixture of foreign substances can be found out. Many vegetable substances, when viewed under it, exhibit characteristic markings or general appearances which serve to identify them and to indicate their presence; whereas, the differences of chemical composition as set out in the figures of an analysis would not be sufficient in themselves to indicate this. We give on this page an interesting series of micro photographs taken by Dr J Augustus Voelcker, Chemist to the Royal Agricultural Society. These show how the presence of certain forms of adulterants can be detected In the top row are given the microscopic appearances of bran [8], coffee husk [9], and a sample of bran adulterated with coffee husk [10]. The cross-linear markings of the coffee husk are very clearly indicated.

In the second row are shown the appearances of linseed [11], corn-cockle seed [12], and of a sample of linseed cake containing these two mixed [13] Rape [14] and spurry [16] are other seeds that frequently occur as adulterants of linseed in linseed cakes. They each exhibit characteristic markings when viewed under the microscope Fig. 15 shows the occurrence of rape with linseed in a sample of linseed cake

Continued

WIRELESS TELEGRAPHY

Oscillations and Waves. Coherers and Other Detectors. Transatlantic Wireless Telegraphy

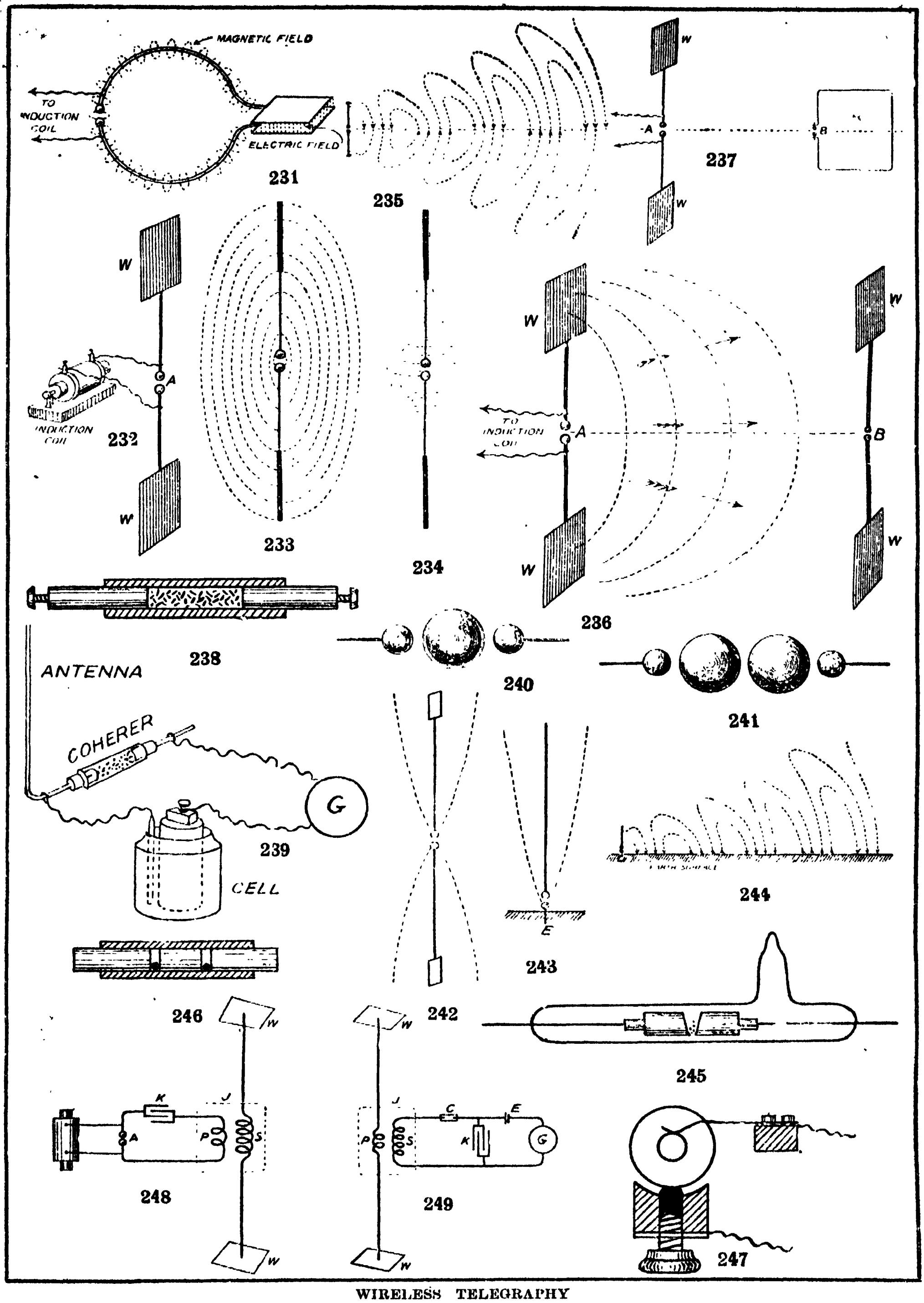
By Professor SILVANUS P. THOMPSON

Oscillations and Waves. In the preceding article [page 3747] it was explained how electric oscillations can be set up in electric circuits in which there is a spark-gap; and the dependence of the frequency of the oscillations upon the capacity and self-induction of the circuit was described. We have now to deal with the relation between such oscillations and the electric waves to which they give rise, and further to explain how such electric waves are made use of for signalling, without wires, from one place to another.

Electric and Magnetic Fields. The first point is to get a clear notion of the *fields* that are set up in space by electric currents and charges. On page 562 it was explained how a current, even in a straight conductor, sets up an invisible magnetic field in the space surrounding it. In that case the field consists of magnetic lines that surround the conductor. Now consider the state of the space that lies between any surface that is charged with a positive charge and a neighbouring surface that is charged with a negative charge. This is the case within the layer of glass, or of air, that is acting as a condenser charged as explained on page 3580. The dielectric, whether air or glass, between the two charged surfaces is, as was there described, in a state of electric strain, there being electric lines of force through it from positive to negative, and these constitute an electric field. Now let us see how these things will be in the case of an oscillating circuit.

An Oscillating Circuit. Fig. 231 represents a simple condenser made of two flat metal plates with a layer of air between them. They are joined by a simple circuit made of bent brass rods, ending in polished balls, with a spark-gap between them, so as to be able to start oscillations, as described in the last article, by connecting them to a suitable source such as an induction coil. Just before a spark passes, one of the metal plates is highly positive, and the other highly negative, and then there will be an electric field across the air space between them. When the spark occurs, the positive charge rushes round the circuit into the plate that was negative, and then surges back again with incredible rapidity, oscillating along the conducting circuit. Each such rush constitutes a current, and as the successive rushes are in opposite directions the conducting wires or rods become the seat of an alternating current of high frequency. Consequently, in the space surrounding the bent wire there will be set up an alternating magnetic field. This magnetic field surrounding the wire will be strongest when the rushing current is at its strongest, and this occurs precisely at the moment when the condenser has been emptied, and before it is charged up again the other way by the continuance of the rush. But the electric field, which will also be alternating, and which lies in the crevasse between the metal plates, will be at its strongest at the moment when the rush either way is completed and the charge in the condenser is at its highest. So we see that with such an arrangement the electric field and the magnetic field occur in different places, and have their maxima at different times. Under these circumstances there will be no electric waves emitted.

Hertz's Oscillator. Suppose now that we open out our condenser into the form shown in 232, where the two metal plates, W W, are extended out like wings, and the communicating conductor, with spark-gap A in the middle, is made straight. The two plates can still act toward each other like the two coatings of a Leyden jar, the surrounding air being still the dielectric. When they are charged there will be an electric field extending from one to the other, as in 233. If a current were rushing up or down the conductor, it would make a magnetic field around the conductor as in 234. And if now a spark is made to pass, setting up a series of oscillations, the electric field between the wings will extend, as the dotted lines show, right across the space where the magnetic field will occur during the rushes of current up and down the rod. The electric field will not have died away before the magnetic field has begun to grow, and vice versâ; so that both kinds of fields can be present in the same space at the same time, and while the electric lines will be mainly parallel to the conductor, the magnetic lines will be transverse whirls surrounding the conductor. *For the production of electric waves it is necessary that there should be both an electric field and a magnetic field at the same point of space and at the same time.* This simple apparatus is capable, then, of throwing off into the space surrounding it an electric wave at each oscillation. Such waves do not return back into the system, but go travelling off into space with the speed of light, following one another as in 235. The more the metal plates present of free surface, the more freely do they radiate off electric waves. If they are of flat metal, the electric waves radiate off more freely from their flat faces than from their ends or edges. If set vertical, they radiate out mainly in front and behind; but they may be set horizontally at the ends of the system. The late Professor Hertz devised this simple apparatus in 1887 for the manufacture of electric waves. It is known as a *Hertz's oscillator.*



WIRELESS TELEGRAPHY

231. Oscillation circuit **232.** Hertz oscillator **233.** Electric field of oscillator **234.** Magnetic field of oscillator **235.** Hertz waves **236.** Waves going to detector **237.** Oscillator and detector **238.** Lodge-Branly coherer **239.** Coherer receiving circuit **240.** Lodge's oscillator **241.** Righi's oscillator **242.** Node in Hertz oscillator **243.** Node in earthed oscillator **244.** Semi-waves of earthed oscillator **245.** Marconi's coherer **246.** Castelli's coherer **247.** Lodge's mercury-wheel **248.** Induction method of coupling oscillator **249.** Induction method of coupling detector

Hertz's Detector. To observe the waves thrown off from the oscillator, Hertz employed detectors which we should now think very inferior and insensitive; but they enabled him to detect the presence of electric waves in other parts of the large room where he was working. He employed a very simple device—namely, another circuit with a very minute gap in it, across which sedentary sparks could be seen to pass. Suppose we make a second piece of apparatus exactly like the first, with two metal plates, as wings, joined together by a rod, but with a minute gap, B, at the middle. The gap must be minute—about $\frac{1}{1000}$ of an inch—otherwise the induced electromotive forces may not be able to make the electricity jump across as a visible spark. Let these two pieces of apparatus, the oscillator and the detector, be set up, as in **236**, a few feet apart from one another in a big room. Let an induction coil or an influence machine be used to excite the oscillator and cause sparks to occur at A, then each such spark sets up oscillation in the metal of the oscillator, and each oscillation sets up a wave in the space around it. These waves spread invisibly through the room, and some of them, of course, fall upon the extended wings of the detector; each wave as it reaches the detector sets up an electromotive force in it, tending to move electricity from one wing to the other and back again, with the result that a new actual oscillation is produced in the metal of the detector, and if the stimulus so received be sufficient, there will be minute sparks seen—a spark at B every time there is a spark made at A. Hertz used principally a detector of even simpler form—namely, a mere ring of wire, or a plain rectangle of wire (as is shown in **237**) having a minute spark-gap in it. When once the sparks have been seen with the two pieces of apparatus a few feet apart, and the apparatus is in proper adjustment, it is easy to detect them when the distance between the oscillator and the detector is increased. Hertz was able to show that these electric waves could be reflected from a large sheet of metal, or collected by a parabolic mirror, or refracted through a prism of pitch; in fact, that they behaved like waves of light, but were quite invisible.

Other Detectors. Very soon other and more sensitive detectors were devised. Righi proposed to lay a long strip of metal foil on glass, and divide it across the middle with a knife, to form a minute spark-gap. M. Branly discovered that a heap of metal filings possesses the very curious property that, though it is usually a very bad conductor for electric currents because of the innumerable imperfect contacts between its particles, it yet becomes a much better conductor when an electric spark is made anywhere near it. Lodge and Fitzgerald found the imperfect contact made by a pointed wire resting against a metal plate to be sensitive to the action of an electric wave. Such imperfect conductors he called *coherers*, because the action of the waves was apparently to make their particles come into better contact. Taking advantage of Branly's observation he constructed *coherers* of metal filings enclosed in a small glass tube between metal rods inserted at the ends; and these proved very sensitive. He found that they required to be tapped after each operation to cause the filings to decohere; and proposed methods of automatic tapping. Fig. **238** illustrates Lodge's filings-coherer.

Coherer as Receiver. The method in which the coherer was used to receive or detect the electric signals is as follows: The coherer is connected to one voltaic cell and to a suitable galvanometer, all included in a simple circuit, as in **239**. The coherer has so poor a conductivity that practically no current passes. Directly an electric wave, however, falls upon the coherer, or upon the wires attached to it, it sets up oscillations, and probably also sets up minute sparks in the gaps between the filings. Whether this be so or not, it makes the coherer conduct better, so that the single cell of battery can send a current through the galvanometer, which thus signals the reception of the wave. The coherer must then be tapped, when the galvanometer deflection at once disappears in readiness for receiving the next signal. Lodge found considerable advantage in fastening on to the end of the coherer an extended piece of wire projecting out as an *antenna* to receive the wave. In some of his early experiments he enclosed the whole of the receiving apparatus in a tight metal case to exclude the effects of any stray waves, the only thing that projected out from the box being the receiving antenna. As such coherers are far more sensitive than Hertz's spark detector the distance between sender and receiver may be increased up to two miles or more, depending on the power of the transmitting apparatus.

Other Oscillators. Various other forms of oscillators were proposed by various experimenters. Lodge found that an exceedingly powerful emitter was made by a single polished metal ball between two smaller balls, as in **240**. Righi proposed two metal balls immersed in oil, and also an arrangement [**241**] of two large metal balls placed between two smaller balls which sparked into them. Marconi patented the combination of a particular kind of receiver with a transmitter having one end of its sparking appliance connected to earth and the other to an insulated conductor. In practice he adopted the device of a tall mast, with a spark-gap between two metal balls, one of which was joined to the mast and the other to the earth. Jervis-Smith found better oscillations if the sparks were made in compressed air.

Waves Emitted by Oscillators. In a simple upright Hertz oscillator such as **235** or **242** the two capacity-areas or plates at the top and bottom ends of the oscillator are the places which become most highly charged, the middle part of the connecting system being, as it were, a node in the potential wave. The same would be true of the same apparatus, if used as a detector; the ends are the places which receive the maximum changes of potential. The middle part, on the other hand, is the seat

of the strongest currents. But this is no longer the case if the oscillator (or the receiver) is earthed as to the lower half; for then the earth takes the place of the lower half, and the node in the potential wave occurs just above the earth, and half-waves [244] are sent out.

"We thus," says Professor Fleming, "arrive at the conclusion that if a vertical rod is set up in the air, and at its lower end there is a spark-ball in opposition to another spark-ball connected to an earth plate, that this arrangement constitutes electrically one-half of a Hertz oscillator; and the system of electric and magnetic force created, when oscillations are set up in the rod by charging it and discharging it across the spark-gap, is the same as that on one-half of a Hertz linear oscillator."

Earthed and Non-earthed Oscillators. Imagine a Hertz oscillator, entirely insulated, 200 ft. high, with its node at the middle as in **242**. Cut off its lower half just below the spark-gap and plant it in the earth: it will then act with the same frequency as before, but will send out waves of a different type—that is, half-waves, with the node at the bottom, as in **243**. Since, in *this* case, the earth takes an essential part in the transmission of the waves, as in **244**, it must be of good conductivity, wet soil, or sea. Earthed apparatus does not work well over a dry desert. The movement of the half-loops of electric force outward from an earthed oscillator—that is, a "Marconi aerial," as distinguished from the non-earthed oscillators used by Hertz, Lodge, and others—is hindered by bad conductivity on the surface of the earth, but is helped by a fairly good conducting surface such as that of the ocean. On the other hand, for non-earthed oscillators emitting whole loops of waves as in **235**, the action of the conducting surface of the earth is no help, or is even detrimental.

As the frequency of the oscillations is determined by the capacity and self-induction of the apparatus, it will clearly depend on the length from the node to the ends, and on the surface it presents; also, any coils introduced into it will increase its self-induction and lengthen the waves. Any oscillator which, like Lodge's polished ball, has relatively large surface and small self-induction, will radiate so freely that the wave-train will die out after very few oscillations. If the wave-train is thus very short, the detector cannot be tuned to it with any accuracy, and any untuned detector within range will pick up the waves.

Early Wireless Signalling. Apart from the researches of Hertz, the earliest exhibition of wireless telegraphing was that of Sir Oliver Lodge, who in 1894 sent wireless signals through stone walls and from one building to another, using as detector a filings coherer as described above, the system being untuned.

There are several modes of using coherers in the receiving circuit. (1) The coherer may be connected in series with a single cell and a galvanometer, or a direct telegraphic instrument, such as a siphon-recorder. This is Lodge's plan. (2) The coherer may be put to earth in circuit with a single cell and a sensitive telegraphic relay, which in turn actuates an ordinary Morse instrument, printing dots and dashes. This is Signor Marconi's method. (3) The coherer may be placed in circuit with a single cell and an ordinary telephone receiver. Thus, at the instant when the coherer changes its conductivity, a click is heard in the telephone. This is the method of Jervis-Smith and Castelli. For use with his method Marconi adopted a coherer consisting of metal filings in a V-shaped gap between two metal plugs in a glass tube, as **245**. For the third method, Castelli used a coherer with two drops of mercury between plugs of iron and carbon [**246**]. More recently, Lodge has adopted as a self-restoring coherer a small revolving steel wheel, slightly oiled, dipping into a drop of mercury [**247**].

Using a Righi oscillator, and a filings coherer with a relay, Marconi was able, in 1896-7, to send wireless signals 250 yards across the Thames; and with the help of the Post Office engineers he sent signals several miles. To extend the range he then adopted the plan, now claimed as essential to his system, of using a tall mast like a lightning conductor one end of which is in good connection with the earth, and called an "aerial wire," or "antenna," or "earthed vertical oscillator." Using masts of 120 ft. or more high, he had, by the end of 1898, been able to signal from 12 to 20 miles.

The Jigger, or Oscillation Transformer. Owing to the circumstance that the simple Marconi aerial resembles the Hertz oscillator in possessing a large radiation decrement, it cannot send out such trains of waves as would be required for syntonic working. In none of these early operations could tuning be secured, and they were liable to interference from stray disturbances in the atmosphere. If a source of persistent oscillations could be applied, the receiving apparatus could then be tuned to the sending apparatus, and the whole system would thereby be rendered far more sensitive for long-distance work. To accomplish this, the sending apparatus must in some way be linked up with an oscillation-circuit, such as was described on page 3749, and the distant receiving apparatus should similarly be provided with an oscillation circuit; then the two can be tuned together to the same frequency of oscillation. There are more ways than one of associating the wave apparatus with an oscillation circuit. The most usual one is by means of an oscillation transformer, called in telegraphic slang a *jigger*, and is due to Sir Oliver Lodge. This induction transformer is a simple arrangement for a primary coil of one or two open turns, surrounding or surrounded by a secondary coil of a larger number of turns.

Increasing the Range. A simple form of Lodge's device is illustrated in **248** and **249**, in the former of which a jigger is arranged for transmitting, while in the latter it is for receiving. J is the jigger, represented by two separate spirals; K is the condenser; A the spark-gap; E the cell; C the coherer; G the siphon-recorder or galvanometer. Apart from the advantage of

tuning, there is another advantage in putting an oscillation transformer into the receiving circuit. For at the node of the receiving circuit the potential is a minimum, and the current a maximum; therefore, as a coherer depends on the potential, and not on the current, the node is a bad place in which to insert the coherer, as was done in the early operations. By placing in the node the primary of the transformer, and inserting the coherer in the secondary, the increased voltage so applied to the coherer was found to increase its sensitiveness vastly, and therefore greatly extended the range of working. Marconi, being desirous of working over still greater distances than those already covered in 1899, adopted the jigger into his receiving arrangements, and was able thereby to extend his range to 85 miles, without even tuning. For transmitting oscillations the transformer was constructed as follows: It consisted of a square wooden frame, wound over with a number of lengths of highly insulated, stranded, copper cable, joined in parallel so as to make a primary circuit of one turn. In some cases, two or more turns may be employed. Over this was wound a secondary of five to ten turns. The oscillation transformer was usually immersed in oil.

Magnetic Detectors. Rutherford, now of Montreal, discovered in 1895 that electric waves can exercise a demagnetising influence upon a highly magnetised small steel needle; and he made a magnetic detector of waves on this principle. He was thus able to detect the waves of a Hertz oscillator half a mile away across the town of Cambridge. The waves produced an oscillatory current, which was carried through a small copper wire coil around the magnetised needle. Seven years later, Marconi described a modified form of magnetic detector, in which an endless band of thin iron wires moving past a fixed magnet becomes magnetised, and is subjected to the demagnetising action of an oscillation coil connected to the receiving circuit. The inductive action sets up sounds in a telephone. Other magnetic detectors have been devised by Wilson and by Fleming.

Transatlantic Wireless Telegraphy. Determined to succeed in sending electric waves across the Atlantic, Signor Marconi, aided by Professor Fleming, constructed a powerful transmitting station at Poldhu, in Cornwall, and has since erected similar stations in Italy and at Cape Cod and Cape Breton. These stations have each four tall lattice towers between which is suspended a conical web of aerial wires. In a power-house an alternator generates powerful alternating currents, which in turn act on spark-gaps, producing oscillations of tremendous energy. From the station at Poldhu signals can be sent from 2,000 to 3,000 miles over the ocean, and have even been detected in the Mediterranean and at the Russian end of the Baltic. The Atlantic liners can be signalled to at any point of their journey, though the apparatus they may carry may not be powerful enough to signal back more than 200 or 300 miles.

German Developments. Professor Slaby, of Berlin, in association with Count Arco, and with the Allgemeine Company, has developed another system. In this an oscillation circuit is associated with the antenna in a way different from Lodge's. Slaby uses a second and horizontal antenna branching off from the vertical antenna near the ground. In this auxiliary antenna the spark-gap can be inserted at a place near the node; and the oscillations set up in the horizontal branch set up a similar set in the vertical one. For receiving, the coherer is inserted in the branch antenna, not near the node but at the other end, between the branch and the earth. For syntonic working, oscillation transformers are introduced between the branch antenna and the spark-gap or the coherer as the case may be.

Professor F. Braun independently developed special arrangements for the inductive coupling of a closed oscillation circuit with an oscillation circuit suitable to emit electric waves. As condensers he used glass tubes partially covered inside and outside with a silver coating.

The devices of Slaby, Arco, and Braun have been taken over by a single interest and operated under the name of the Telefunken system. The name Telefunken signifies distant sparking

American Developments. In the United States several inventors, De Forest, Fessenden, Stone, and Shoemaker, have devised particular methods of wireless telegraphy, all of them claiming certain advantages. De Forest has produced several forms of detector which do not depend on the coherence between metallic powders or imperfect contact, but upon electrolytic phenomena. It was previously known that a film of moisture between two strips of tinfoil on a glass plate would act as a detector, and required no tapping. De Forest has used two small electrodes in water, in circuit with a telephone. Like Marconi he employs a tall mast. Fessenden has devised a detector consisting of a very thin platinum wire sealed into a glass bulb. The feeble oscillations which are set up in the receiver, passing through this wire, heat it, momentarily increasing its resistance. This device he calls a *barretter*, and it is included in a local circuit with a single cell and a telephone. He has found that a liquid barretter can be made with an electrolyte in a glass tube of extremely fine bore. This acts in the opposite way by decreasing its resistance.

Present Position of Wireless Telegraphy. Briefly, the present position is this: For the Atlantic service, the Marconi Company stand alone, and they have equipped the principal passenger ships of the Cunard and other companies. A much greater number of stations (over 400 altogether) in various parts of the world have, however, been equipped with a different system, that of the Telefunken Company. For overland service, on account of its not using any earth connections, and for its great perfection in working, the Lodge-Muirhead system is distinctly ahead.

Continued

AUSTRALIA & NEW ZEALAND

South Australia. West Australia. Tasmania. Physical Features, Products and Towns of New Zealand. The Pacific Islands

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

SOUTH AUSTRALIA

SOUTH AUSTRALIA was first settled, as the name suggests, round the inlets of the south coast. It now stretches across the continent and covers 903,700 sq. miles, the northern part forming the Northern Territory [135, page 3699]. Settlement is at present mainly confined to the south.

The colony, as a whole, is flat, though in the centre the Macdonnell and James Ranges reach 5,000 ft. In the south the Flinders Range rises west of the Murray, and is continued by the Mount Lofty Range, overlooking Adelaide. Much of the southern part is a region of lakes, some, like Lakes Eyre and Torrens, being large, but varying greatly in size at different seasons, others being mere chains of lagoons and holes. All are salt and low lying, Lake Eyre being probably below sea-level. The only river of importance is the Murray, which enters the sea through Lake Alexandrina.

Climate and Resources. The Northern Territory lies in tropical latitudes and has a heavy summer rainfall along the coast in the monsoon region. Both summer and winter temperatures are high. There are tropical forests along the coast, which is fringed with mangroves, while there are dense thickets of paper-bark tree along the rivers. The centre is dry, and passes into desert. As the south coast is approached, the salt bush appears, forming a poor pastoral region on which one sheep per ten or more acres is the utmost that can be supported. The rainfall of Adelaide is about that of the drier parts of England, and falls chiefly in winter. Long spells of drought are very common, and seem to recur periodically.

Much of the Northern Territory will never be anything but desert, but if underground water could be tapped by artesian wells, large tracts might be made available for pastoral and agricultural settlement. In the southern part of the colony sheep farming is by far the most profitable employment, but agriculture is spreading in the Murray Flats, and may develop with irrigation. A considerable acreage is under wheat, but though the quality is very fine, the yield is extremely scanty. Soil and climate are suitable for fruit growing, and the vine, fig and olive do well. The mineral wealth is chiefly in copper. [See AGRICULTURE, page 3236.]

Towns. The towns of South Australia are generally small townships of a few hundred inhabitants. Adelaide, the capital, is finely situated on the Torrens, near the base of Mount Lofty. The city has fine streets and buildings, and is surrounded by a broad belt of parks. Mount Gambier, in the extreme south-east, near the Victorian boundary, is the centre of a fertile district. Gawler, north of Adelaide, is in a wheat growing district. The richest copper mines are at Wallaroo, on Spencer Gulf, and at Moonta, a few miles inland. In the Northern Territory is Palmerston, overlooking the fine harbour of Port Darwin.

WEST AUSTRALIA

West Australia (975,000 sq. miles) is the largest of the Australian colonies. The greater part of the interior consists of a waterless plateau, dotted with lakes, which, in the dry season, are glittering surfaces of dry salt and mud, and filled with brackish water after the infrequent rains. This plateau comes down to the sea on the south coast, forming the harbourless cliffs of the Great Bight. Along the west coast its higher margin rises above the coastal plain, which is of varying width. In the Stirling Mountains, which rise behind Albany, these marginal heights reach 3,500 ft. in the extreme south; but in the Darling Range, which runs north for 300 miles, they do not exceed 1,500 ft. Further north, the plateau margin recedes 200 or 300 miles from the west coast, rising in the Kimberley region in the north to 2,300 ft. [135, page 3699.]

The rivers are confined to the western coastal region, rising in the highlands already mentioned. As the interior is extremely dry, many of them are mere empty watercourses, except after rain. The Swan, at the mouth of which Fremantle has been constructed, is the most important.

Varieties of Climate. The climate of West Australia is tropical in the north, with a summer rainy season. This forms the Kimberley region, the coastal portion of which bears tropical forests, and permits of stock-keeping in the river valleys. Among the stock are camels, introduced from India and South Australia for transport in the desert interior. Away from the coast, the climate rapidly becomes extremely dry, and the greater part of the colony is stony or sandy desert, bearing little vegetation but the dreaded spinifex. A tongue of desert, marked in maps as the Eighty Mile Beach, extends to the coast north of the De Grey River, separating the Kimberley region from the more temperate portions of the colony. In the latter the summers are cooler, and the rainfall along the coast moderate in quantity. The most thickly settled portion is the coastal strip from Geraldton to Albany. Most of this region has a Mediterranean climate with winter rains, and can raise cereals and fruits, the vine and orange doing especially well. The forests of the south-west contain magnificent timber, including the gigantic jarrah and karri eucalyptus. Away from the coast the plateau is extremely dry, and the population has not penetrated

more than 500 miles inland, attracted by the sensational discoveries of gold. [See AGRICULTURE, page 3235.]

The Rush to the Goldfields. A solid belt of auriferous country, only interrupted by the Eighty Mile Beach, appears to stretch along the edge of the plateau from north to south. The tropical goldfields are difficult to develop, owing to the exhausting nature of the labour, which in these latitudes cannot be done by white men.

In 1891, the population of the whole colony was under 50,000, but the discoveries of 1892 in the Coolgardie region immediately led to an inrush of population. "The track, which ran eastwards through the primeval bush, was a curious sight in those days. Heavy waggons, laden with flour, chaff, and whisky, lumbered axle-deep through the mud, drawn each by its team of a dozen great horses in single file, for 1893 was a wet season." Now, a railway from Perth runs to Coolgardie and the surrounding goldfields, the richest of which is Kalgoorlie, some twenty miles beyond Coolgardie, in the desert. To drive the engines and fill the sluices of the Kalgoorlie mines, water is pumped for more than 200 miles through steel pipes from reservoirs near the coast. At Kalgoorlie is the famous Golden Mile, containing half a dozen of the richest mines known. Other well-known fields are the Murchison, the Yalgee, the Yilgarn, the Mount Margaret, and the Dundas, and many rich goldfields are doubtless waiting discovery. The pioneer prospector in these waterless regions takes his life in his hands, and should he be successful, and return safely to civilisation, the almost prohibitive difficulties of transport and water supply have yet to be overcome. The cost of living on the goldfields is extremely high, and since the inrush the colony is unable to raise food enough for its population. The total value of the gold obtained in West Australia in 1903 was approximately £8,770,000.

Towns. Perth, the capital, is situated on the Swan River, some ten miles from Fremantle at its mouth, the chief port of the colony. Geraldton, the most important town north of Fremantle, is the port for the Murchison district, which, in addition to gold and minerals, produces wool. Cue, the chief town of the Murchison Goldfields, is some 300 miles inland. Coolgardie and Kalgoorlie are both connected with the capital by rail. The chief town in the south is Albany, on King George's Sound, a coaling station for the British Navy, and a place of call for many steamers.

TASMANIA

Tasmania (26,000 sq. miles) is somewhat smaller than Scotland, which it rather resembles in scenery. The interior consists of a plateau, cut by the valleys of the rivers, and rising, in Ben Lomond in the north-east and Mount Cradle in the north-west, to over 5,000 ft. [137].

The picturesque lake, river, and mountain scenery make Tasmania a favourite summer resort for Australians. Lying in the track of the westerly winds, it has an equable climate, not unlike that of Southern England, and rain at all seasons. At the time of its discovery it was covered with forests, which have been partly cleared for agriculture and sheep farming. They still provide valuable timber, including eucalyptus of giant size. In addition to sheep farming, much attention is paid to fruit growing, and Tasmanian apples are largely exported. Hops are also grown, and the usual temperate cereals.

The capital is Hobart, at the base of Mount Wellington, on the Derwent, which flows to the dangerous but picturesque Storm Bay. Launceston, on the Tamar, is the chief port in the north.

NEW ZEALAND

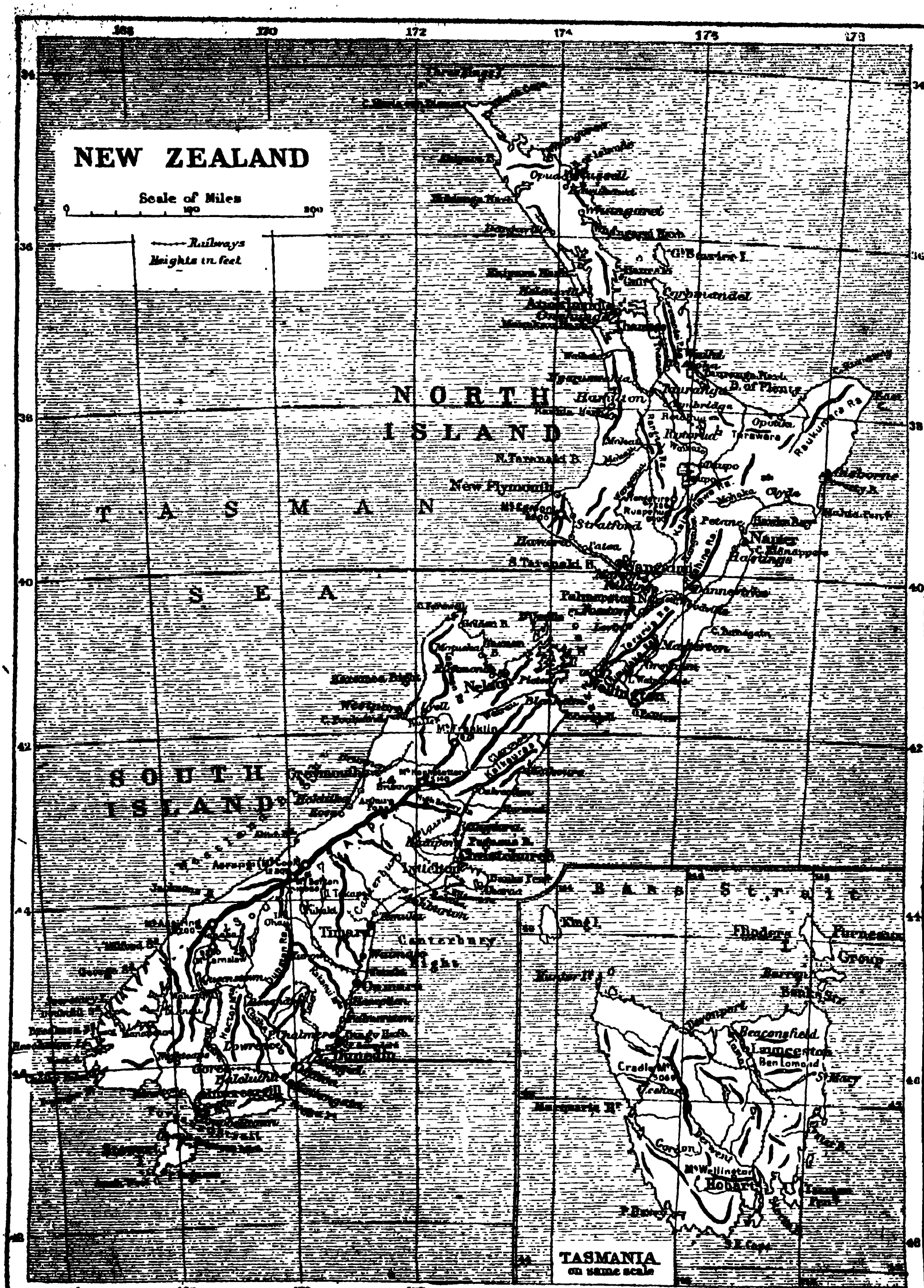
New Zealand (104,750 sq. miles) consists of the large islands of North Island (44,500 sq. miles), South Island (58,500 sq. miles), Stewart Island (665 sq. miles), and many smaller islands.

New Zealand turns, as it were, its back to Australia. The west coast of South Island is deeply cut by magnificent fiords, but these give access only to lofty and inaccessible mountains, whose glaciers descend to within 1,000 ft. of the sea. The west coast of North Island, though lower, has no good harbours, and access is from the east, where all the important harbours are situated. Cook Strait, which separates North and South Islands by thirteen miles of sea, has good harbours on both shores.

Mountains and Rivers. The west coast of New Zealand is almost everywhere high. In South Island it is bordered by the Australian Southern Alps, rising to the height of the Bernese Oberland in Mount Aorangi or Cook (12,300 ft.). The New Zealand Alps contain fine glaciers, and their scenery is of true Alpine character. They are continued to the south by the mountains of Stewart Island, and to the north by the western mountains of North Island, which reach 5,600 ft. West of these western mountains of North Island, and quite independent of them, rise three volcanic cones. Ruapehu (9,000 ft.) and Tongariro (7,500 ft.), with its triple summit are still active, but Egmont (8,200 ft.), rivalling Fujiyama in its faultless symmetry, is extinct. The surrounding region, with its geysers and hot lakes, is one of the most interesting volcanic districts in the world. The famous pink and white terraces were destroyed by the eruption of Tarawera in 1886. The Western Highlands give rise to many rivers, which flow east following the slope of the country. They are of no great use for navigation, being either too swift or too shallow. The lower eastern half of New Zealand is the settled portion.

Climate. The climate of North Island is considerably warmer than our own, the summers averaging from 65 degrees to 68 degrees, the winters from 48 degrees to 55 degrees. The climate of South Island is not very different from that of Southern England. The islands lie in the path of the west winds, and their western coasts receive heavy rains. East of the mountains the rainfall is lower, but sufficient for agricultural purposes.

Vegetation, Resources and Occupations. The wetter parts of New Zealand are densely forested, evergreen pines and beeches predominating. One of the finest trees is the kauri pine of North Island, which yields



137. NEW ZEALAND AND TASMANIA

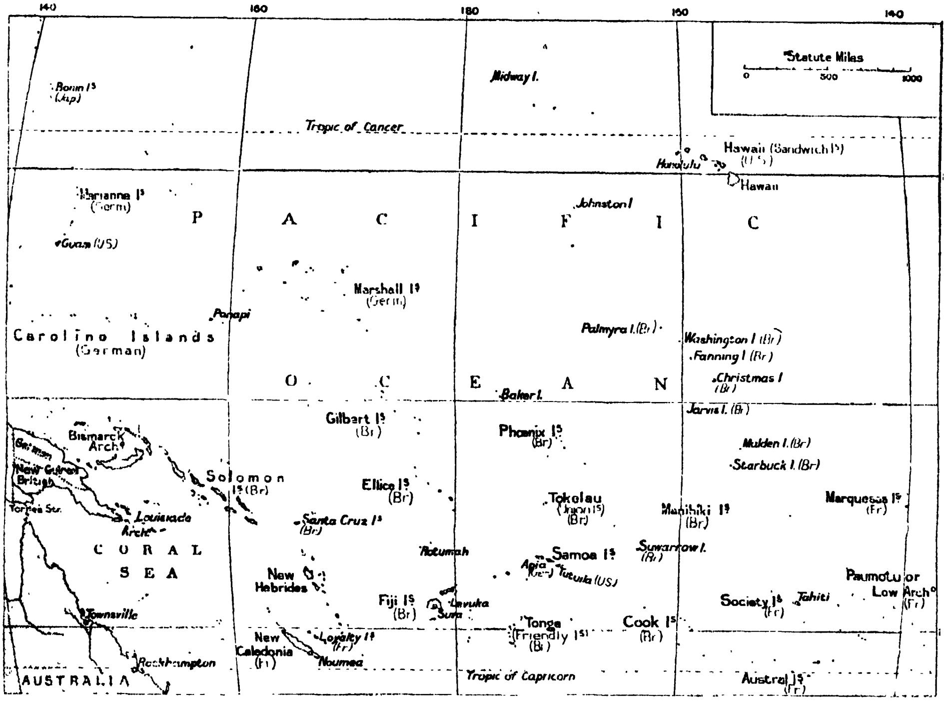
magnificent timber and a valuable gum. Large quantities of this in a fossil state are obtained.

The drier eastern regions are grass lands, originally covered with fern or coarse grass. Much is now sown with European grasses. On these grass lands are grazed enormous numbers of sheep, bred for meat as well as wool. A large trade is carried on in frozen mutton, which is exported in steamers fitted with special refrigerating chambers. Cattle are also bred, especially in the west, and the dairy industries are rapidly growing. Much frozen butter is exported. Other occupations depending on the pastoral industry are wool-washing, bone-crushing, boiling down, tanning, and such manufactures as boots and shoes and woollens.

isthmus, with a harbour on either side. Thames, Napier and New Plymouth are smaller North Island ports. In South Island, Lyttelton is the port of Christchurch, on the Canterbury Plains, which have a southern port in Oamaru. Dunedin, and Port Chalmers on Otago Harbour, and Invercargill, on Foveaux Strait, are the chief southern, and Hokitika and Westport the western ports.

THE PACIFIC ISLANDS

The Pacific is studded with island groups of which the most important south of the Equator are the Solomon Islands (British), the New Hebrides (under British and French protection), Fiji and Tonga (British), Samoa (United States and Germany), Society and Marquesas (French).



138. THE PACIFIC ISLANDS

Agriculture is increasing in importance. Oats are the principal cereal, and wheat, which has a much heavier yield than in Australia, is grown in the Canterbury Plains. Potatoes are an important crop. Fruit growing is not yet important, but might easily become so. [See AGRICULTURE, page 3466.]

New Zealand has valuable minerals. In 1903 the output of gold exceeded £2,000,000, chiefly from the Thames basin in North Island, the north-west of South Island, and the river sands of the south-east of South Island. Coal is mined in several places, but much has to be imported.

Seaports. The capital is Wellington, on Cook Strait in North Island, but the most important town is Auckland, on a narrow

North of the Equator are the Marianne and Caroline Islands (German), and Hawaii (United States). All are either highly volcanic, densely forested islands, or low coral islands with little vegetation but coconut palms. Economically, the most important are Fiji, Samoa, and Hawaii. Rice, cotton and sugar are grown in Fiji and Hawaii, and all the islands supply more or less copra, the dried flesh of the coconut. The chief centres are Honolulu on Hawaii, Apia on German Samoa, the United States naval harbour of Tutuila on Samoa, and Levuka and Suva in Fiji. The French island of New Caledonia (8,000 sq. miles), between New Guinea and New Zealand, is a penal settlement. It has great mineral wealth and is the chief source of nickel ore.

Continued

AUTOMOBILES

Goods Vehicles. The Commercial Motor Body. Metal Construction and Weight Cutting. Pleasure Vehicle Design. Coachbuilders' Machinery

continued from page 3779

By H. J. BUTLER

OUR railway trains run on fixed highways, and therein lies one of their greatest drawbacks. Most railway companies look to the carriage of goods as the chief source of income, and there are instances where it has been the sole object for which the railway was formed. In the United Kingdom there are about ten times more goods railway vehicles than passenger vehicles, and one-eighth more receipts from the former traffic.

Flexibility of the Motor-car Service. The motor-car is not confined to a set of iron rails, and it may be loaded up at the warehouse and despatched direct to the customer without the expense of any intermediate handling. We may therefore look forward to the development of the commercial motor in the near future, and probably it will benefit commerce as the railway has so magnificently done. By the adoption of motors we do away with the dangers of two-wheeled vehicles and falling horses.

For carrying the mails, the Government are adopting the new traction in many types, from the tricycle carrier up to the large mail van. The market gardener brings his fruit and vegetables quickly to Covent Garden or other distributing centres without delay and in safety. Very often he has been glad to accept the new state of affairs, owing to the behaviour of the railway companies in charging rates that are very high in comparison with the charges made for transport from the Continent and America. Those who have many calls to make—as commercial travellers or carmen—find that they cover more ground in a day by the use of a motor-car.

Goods vehicles are not only in the majority on the railway, but horsed vehicles are also used chiefly for commercial purposes. Therefore it is seen that vehicles are designed principally for the distribution of goods.

The Commercial Motor Body. As Motor Engineering is discussed elsewhere in this EDUCATOR, the bearing that mechanical improvement will have on the development of the transport of goods by motor will not be dealt with here. Still, the question of the bodywork, so often ignored, is worthy of attention.

Frequently we see bolted to the châssis a mere box, often badly finished and designed. Sometimes the body is projected too far over the hind wheels, which not only looks bad, but is a continual source of skidding. The motor-car manufacturer often makes his commercial châssis sizes without consulting the coachbuilder, and he absolutely refuses to alter them until he is compelled either by losing the support of his customers, or by his rivals designing more useful frames. No doubt, a short and narrow châssis is desirable where possible, but a little more width and more regard for a useful length of châssis behind the dashboard is essential, if serviceable bodies are to be designed.

The Engineer's Shortsightedness. Another cause of unsatisfactory bodies is the fact that the body is often entrusted to the motor engineer, or to his specifications. He generally has little respect for the superstructure, considering it a mere item of the whole. In many cases he insists on the lowest possible price, and binds the coachbuilder to delivery in so short a time that good workmanship is impossible. Nevertheless, the motor-car engineer grumbles just as if every advantage had been given to ensure a highly finished useful body. One cannot expect the body-builder to spend any time in evolving fresh designs, or taking particular care in little details and the general effect, if every inch of stuff and every minute of time must be considered. Let the body-builder have a fair price and time to do his work.

Design for the Laundryman. This trade requires a van designed to facilitate distribution of the hampers of clean linen. When collecting the soiled linen, no special arrangement facility is necessary, but much time will be saved if the van may be unloaded from a side divided into shelves, so that one hamper may be removed without disturbing the others. The safety of the contents will be increased if the floor slopes a little to the centre. Most châssis are built lower on the ground than the horsed type, and this is a great advantage, as the hampers are more easily handled. The whole may be roofed over, and to the roof a luggage rail may be attached for taking extra hampers, especially empty ones. From the edges of the wooden canopy, waterproof side curtains, which may be drawn out of the way in fine weather, should be attached.

Ice Motor Waggons. In the distribution of ice to fishmongers, hotels, and other establishments, we see a very useful application of the motor. We can understand why ice should reach the customer without delay. The vehicle body should be isolated from the heat of the engine, and the space between its double panels packed with a non-conducting material, such as felt. Improvements in draining the body are certainly wanting in some of the horse-drawn types, where the results of melting are allowed to drip all over the undercarriage. The quicker the interior of the body gets rid of its superfluous moisture, the longer the ice will keep. The inside might be lined with zinc, while the ice blocks in their encircling blanket stand on narrow wooden laths, the water running down to a metal floor,

which, for preference, should be drained towards the centre and to the rear. Railway waggon floors are drained in this manner.

Fruit Motor Waggons. The carriage of fruit also demands care and promptitude in its despatch. Lately, we have been confronted with the large supplies of bananas that reach these shores. The Great Western Railway has done signal service in bringing the supplies promptly to town, and when punctually met at the station by the road van, their deposit at the wholesale fruiterers in a perfect condition is ensured. Fruit often requires to be protected from extreme cold or heat, and contact should be prevented as much as possible. Properly ventilated vehicles arranged either to accommodate hanging bunches or to take on its shelves and partitions small baskets, is the most serviceable design.

Mail Conveyance by Motor. The remarks concerning the design of the laundry van might be applied with advantage to the construction of the vehicles carrying the parcel hampers and letter-bags, although extra means for safeguarding the load must be provided. This side method of loading is certainly useful for emptying quickly, which is necessary with postal work, and we may note a passenger parallel in the method of seating the firemen on the manual or steamer. We cannot fancy our friends in the brass helmets sitting face to face in a waggonette and descending calmly one by one from a narrow downway to a narrower step and finally to the ground. No, they jump in a group before a door handle could be turned.

Commercial Travellers' Motor-cars. There have been many attempts to provide a useful vehicle for the traveller. It is necessary that he should get into his car easily, and not be perched aloft as in some undesirable patterns. If he can take hold of a box of samples before he leaves the car and without going to the back, so much the better. He should therefore sit facing towards the side of the car a little so that the opening immediately behind his seat may allow him to enter the body proper, where there is just room for him to turn round with all his boxes arranged on shelves around him. The interior may be lighted by a small skylight or a neat electric lamp.

Doctors' Motor-cars. A doctor should keep to the old order of things unless he can afford a small medium-powered single landaulette with roof extension to the dash with the chauffeur seated on a single central seat. He has few things to take with him, and this type of vehicle is at once dignified and suitable for all weathers. Why a rabbit-hutch contrivance in which both the professional man and his chauffeur are boxed should be considered desirable is a matter requiring much reflection. The landaulette need not be made wide enough for two between the standing pillars if it be necessary to reduce weight to a minimum. A width of 2 ft. 9 in. allows of a comfortable seat and room for a bag and books of reference.

Cars for Heavy and Light Bulky Loads. Hitherto when transporting heavy material such as boilers and machinery, it has been found most economical to use ordinary horse-drawn vehicles coupled to a small traction engine. Most of the heavy motor lorries are quite as high as the horse-drawn types. With mechanical improvements we shall probably have cranked bodies as we have seen in pleasure car châssis, such as the Darracq and Talbot. Bulky loads, such as farm produce, and empties are often carried by means of trailers.

Front-driving Motors. A motor coupled up to the front wheels, such as the "Latil," is useful when desiring a motor van to carry theatrical scenery or long lengths of timber. The transmission of the power to the far away hind wheels would mean great loss of power and entail an amount of heavy shafting, etc. This type of motor might be made useful for the transport of other light bulky loads besides scenery.

Motor Omnibuses. Perhaps the chief way in which the utility of the motor-car is impressed upon the general public, especially those who cannot afford to possess one, is by means of the public service vehicle.

The electric tramcar partakes of both the railway and the motor-car, but the "'bus," be it single or double decker, is an automobile proper. Rather than see how many passengers we can crowd on a certain châssis, it would be far better if each passenger were allowed a little more room, even at the expense of reducing the carrying capacity by three or four. It is the untiring effort on the part of the different companies to wedge their customers into the smallest possible legal space, and this is the reason why the corridor carriage is not yet more generally adopted on our railways. Motor 'bus promoters, who grumble so much at tramcars, will do well to copy some of the interior comforts of the latter.

Having constructed the body of the best material, teak being more preferable than ash, and sufficient time having been allowed for the hardening of the last coat of varnish, we should expect to find a well-designed body with the majority of the following details.

Seats and Seating Accommodation. Each inside passenger should have at least 17½ in. of sitting-room, and a brass rail should be supplied to divide the passengers into two divisions in order that the proper seating accommodation may be easily obtained without recourse to individual divisions.

The overall width of the roof should be not less than 7 ft. 6 in., which will not exceed in most cases the overall of the hind mudguards, and the garden seats each seating three persons might be placed in the centre of the roof, a gangway being provided on each side. This garden seat should be made so that a slight dip tends to keep the passenger centrally rather than towards the gangways. Much of the discomfort caused to outside riders might be minimised if a set of springs, painted or covered with waterproof material, were placed between the seat laths proper and a foundation. If the usual method of roof seating with central gangway be adopted the same overall width should be maintained. The height of the roof in the centre being kept the same, the

sides should be higher, so that less arch and consequent less discomfort may be given to the passengers, besides allowing of more ventilation inside. A fare table should also be visible to the outside passengers. The cross seating has been tried for the interior, but while the drivers and his levers etc., are between the passenger and the view, not much comfort is added. It is certainly a favourable method when the body is open-sided, as in some patterns of tramcars, or if of the *char-a-banc* type.

Staircase. Again we plead for a few more inches, this time in the width of the treads. If one or two more risers and treads were inserted, the difference in comfort, especially for ladies, would be appreciated. But the staircase, whatever its pattern, is, after all, only a necessity owing to the public demand for a roof seat, as the omnibus and tramcar have become a means of pleasure in the form of an enjoyable ride. The proper development of the single decker has much before it, especially for country roads. We might add 12 in. to the head room of existing types and go on devising drop sashes till they do not rattle.

Curtains and Other Fittings. Such items as curtains are best in the spring roller type, and as there are firms who have supplied them in their tens of thousands to railway companies, there is no need to argue that a proper fitting has not been devised. Small electric pushes may be fitted as in tramcars to arrest the vehicle when the conductor is on the roof. Advertisements should be entirely banished from the interior, and illustrations and descriptions of places of interest en route allowed to take their places.

Lighting and Heating. The lighting of the interior should allow each inside passenger to read with comfort after dark, an electric lamp over the shoulder being best. Heating is easier with steam systems than with the petrol type. We have yet to see the evolution of heating systems in road vehicles.

Suspension. The châssis being hung on springs strong enough to take the maximum load and of sufficient length to absorb vibration easily, there is no reason why the body should not be suspended on a set of springs of its own. In steam rail motor coaches we see the front end of the passenger body resting on a movable bolster provided with springs, the whole resting on knife edges. This tends to isolate the body from the vibration of the engine. Possibly this can be adopted on the motor 'bus.

Announcement of Destinations. Where the 'bus goes, where it comes from, and the direction in which it is travelling should be made quite clear by day and night. The two sides of the vehicle should be taken up with the names of the chief places passed through during the journey, each side reading the same, except that the near side should always read from left to right and from top to bottom, the different roads and streets in the order that they are passed in the way the 'bus is travelling should be recorded. The front should be simply inscribed with a visible sign announcing the terminus, and the rear should be similarly fitted. Both should be capable of illumination at night.

Advertisements must be kept above the roof line, and should not be placed on the windows. If this were done, advertisements would not be confused with the destinations, and light would be allowed free ingress into the interior.

The route naming that is becoming fashionable with motor omnibus companies is to be upheld if it does not confuse the stranger. "Vanguard," "Ensign," "Pioneer," "Arrow," and such words denoting enthusiasm and enterprise should not take up the best part of the side panel and crowd valuable space which should be allotted to the destinations. The public are quite likely to associate a certain name with a certain route, and as the cars are continually being transferred to other routes confusion is caused.

Improvement of Motor 'Buses Possible. The old omnibus companies that have used the horse for many years past find that the expensive quadruped has brought them better dividends than railways. They should be able to adopt all the improvements suggested on a motor omnibus service without decreasing their returns or the pay of their employees, as the new form of traction is cheaper.

The mechanical omnibus is in its infancy, and is certain to develop into comparatively general use. This will come all the sooner if the newly formed society of Motor Omnibus Engineers has among its members a moderate proportion whose thoughts are not confined to sparking plugs, silencers, and such things.

Influence of Motors on Other Vehicles. The coachbuilder has in some instances copied the motor body types in his latest productions for horse traction. Governess cars, from which the tonneau was partly evolved, have been made with top panels carrying the back squabbing very similar to the motor body types. Bucket-shaped seats have been adopted in phaetons—including victorias—as well as in sociables, and the revival of the motor landaulette has seen an awakening among the horse-drawn types. The tonneau phaeton is practically a tonneau motor body on the coachbuilder's under-carriage, and it might be yet more successful as a novelty if it were hung lower and made easier to enter.

The railway companies have felt the presence of the automobile. Not only are they adopting motor omnibuses and *char-a-bancs* to bring customers to the railway stations, but they are bringing up to date an old type which is now known as the *rail motor coach*. In the majority of cases it is driven by the much tried steam power, and we yet have to see the adoption of the petrol motor, such as the Great Northern Railway Company are trying, to this new type of body. The influence has been felt even among mail carts, for the youngster can now be provided with a pedal-driven motor car, and if its parents can afford them, such details as lamps, goggles, horn, etc., may be included, in order that "playing at motors" may be carried out thoroughly.

The Old Compartment Trailer. We notice with pleasure that the rolling stock of the new motor coaches is either of the saloon or corridor type. The renouncement of the compartment type in these vehicles as well as in tube trains and other new electric rolling stock, will help to expel them from the main and suburban lines. In public service vehicles, safety lies in company. It has been shown time and again that the compartment system is fraught with danger.

Weight Cutting. The motor-car trade has revived the use of constructional metal work in vehicles. Aluminium panels, framework angle and moulding, when of good quality, are lighter, and necessitate less labour in the painting, although, perhaps, they do not give quite so durable a finish. The metal panel is also better adapted to quick turns, yet in some cases, where we have a return curve in the turn-under together with a side sweep, we find that such a panel keeps its shape better if of mahogany. The side panel in a curricle-shaped body is an illustration of this.

Still, the experienced metal-worker who is used to the eccentricities of the material will more likely be successful in turning out a piece of work that does not offend the eye whichever way it be viewed. Perhaps the most aggravating part of a thin metal panel is when it has a slight dent, not enough to warrant an expensive repair, yet sufficient to spoil the beauty of an otherwise good surface.

Metal hoopsticks may be seen in motor omnibuses carrying the roof, and the use of aluminium castings will do much to reduce the dead weight.

Metal Railway Waggons and Coaches. Railway waggons are now sometimes built entirely of metal. This applies not only to the medium types, but also to the new varieties of high capacity waggons with the varying method of discharging the load. The passenger railway vehicles are also being designed with panels and other parts of metal. By carefully apportioning the various sheet thicknesses and sectional strengths of the various members, not only have we obtained a fireproof carriage, but the total weight has been reduced. This is a consideration in the tremendous weight which corridor carriages have attained during the last eight or nine years. Increase of comfort has done this, for cooking stoves, dining tables, refreshment bars, sleeping berths, especially one-berth compartments, heating and lighting apparatus cannot be provided without adding to the weight. They all, more or less, take up room that might be occupied by a passenger.

As far back as 1898, American railway carriage designers came to the conclusion that 100,000 lb. was an enormous weight for a car, even if it were some 70 ft. in length. British builders, less eager to crowd their stock with every comfort, have not erred so greatly as have the Americans. The Brush Electrical Engineering Company, Limited, are to be congratulated on the new type of steel coach they have built for the Great Northern and City Railway, the electric tube railway running from Finsbury Park to Moorgate Street. Here, the weight per passenger has been reduced to 637 lb. A modern dining coach seating 20 will often weigh nearly double as many tons, while even a saloon carriage holding 56 passengers will work out at nearly half a ton per passenger.

Pleasure or Private Motor Vehicle Design. In a commercial vehicle we naturally expect the interior to be as useful as possible. The exterior, bounded mostly by straight lines, will fulfil its purpose in ordinary cases if neatly finished without any recourse to excess of decoration. Probably the enterprising and up-to-date tradesman will get better value out of his motor vehicle if he paints and inscribes it in a striking manner, as previously suggested, but this does not require curved boundaries for its display. In a gentleman's touring car we may be excused if we desire further to embellish the body after the seating and other accommodation has been properly arranged.

We must have a straight line if the panel ends at the seat line and where the rocker joins the top of the frame, if it be of the ordinary pattern, but there are many instances where a flowing curve may be used with advantage. Some designers have considered that any line deviating from the stiff straight line and an abundance of scrolls and dub ends gives a beautiful effect. But anyone who has the slightest artistic pretensions will allow that the fewer and simpler the lines necessary to carry out a body, the more pleasing is the effect and the more lasting the pleasure so created.

French Taste. Without being accused of want of patriotism, we do well to closely notice the style of outline which the best French taste dictates. We find that the lines flow. As we follow the outline, it never seems to lie still or remain flat in any place. We shall find in a Roi des Belges tonneau that the line that bounds the top extremity of the seat panels is a beautiful curve the whole way. There is scarcely a spot where a straightedge would find a resting place, even for an inch, and yet there is nothing exaggerated in the appearance.

Owing to its shape, a $\frac{7}{8}$ in. half-round moulding gives more reflection to the varnish, thereby imparting a lighter appearance, and the size suggested, when increased, is inclined to give a heavy effect to the whole.

Front Seats and Doors. The position of the chauffeur's seat is generally determined by the pedals and steering wheel. The occupant of the seat beside him, not being bound by any mechanical considerations, may encroach a little on the space between the front of the seat and the dash, thereby securing a more roomy seat, yet keeping the backs of the two front seats in line. Lightly constructed doors are useful in keeping the draught from the legs of those on the front seats. In designing the top line of the doors, it is desirable that it should not be a continuation of the front seat line, but swept gently upwards.

A doorway less than 20 in. wide gives little comfort to the passenger or quitter, and 22 in. is the normal width with the horse-drawn type

for side entry. The engineer's designing of the châssis often results in the right-hand bottom corner of the door being cut away, owing to the nearness of the hind wheel and wing.

Lighter Appearance of the Body. Round corners at the back give a pleasing and lighter appearance, although they are, no doubt, a little more expensive to construct, especially when a piece of curved glass is included. Glass itself gives a light appearance, but it must not be forgotten that a sheet of plate glass is heavier than a corresponding area of mahogany or aluminium. The use of imitation cane-work, if it coincides with the customer's taste, is also useful in doing away with a heavy appearance. But it must be put on with due regard to bevels and round corners, otherwise it will be unsightly. It is a pity that the hand method has been superseded, for in it there was more chance of every allowance being made for the direction of the surface. Striping and shamsticks must be quiet, otherwise attention is detracted from the outline of the body.

Demand for New Types of Bodies. The automobile salesman is asked by some of his customers to construct bodies involving wonderful ideas, many of which are practically impossible of realisation. Although some foolish designs have been the result where the purchaser has insisted against the advice of those who are experienced, yet the effect, as a whole, has been to invent many fresh designs in seating and other arrangements, as well as in the general conformation of the body.

The Future. Towards the end of the year 1906 we find that Great Britain is turning out automobiles equal in performance to those made in France. As yet, the pleasure car is in the ascendancy; but no doubt time will bring proportions of other vehicles. The Show at Olympia is an evidence of the popularity as well as the prosperity of the new method of locomotion, and already the technical Press, the finest in the world of its kind, as well as newspapers and magazines, show what a tremendous hold it has.

It is, from the automobile point of view, a foregone conclusion that the man of the future will be more of an engineer than his father. Cycling developed mechanical thought; railways, interesting thousands more than they actually employ, have fostered it, so automobilism will find a prepared field upon which to work, and a wide scope.

We cannot believe that the horse will be entirely superseded, for it has already withstood the advent of the "iron road," but it may be safely prophesied that few omnibuses, tramcars, medium and heavy vans, will be horse-drawn some ten or fifteen years hence.

We have seen that the railway is primarily a carrier of merchandise. Is the automobile to develop in the same direction ?

Coachbuilder's Machinery. We have seen that in factories with large output, and especially in those where repetition work is turned out in quantities, wood-working machinery is an absolute necessity. Apart from the different tools, each doing their own special work, we find several types of motive power. In medium sized and large factories the steam engine has for some time held its own, but lately it has been used to drive a dynamo, so that neat little electric motors may be coupled up to each machine. Anyone who has seen an old factory converted from direct steam power, with its endless bands and pulleys, to electric power, will appreciate the saving of space, the better light, and the cheaper working gained by the newer practice. It may be that the manufactory can draw power from an electric main, in which case the steam engine is not wanted in the factory. Gas engines find favour in small shops, and need no boiler, chimney, or coal. Also the power is set in motion or arrested as required, and is specially valuable where the work is intermittent.

Petrol Stationary Engines. The petrol explosion motor by no means finds the only outlet for its energy in propelling road vehicles. It is unnecessary here to consider motor boats and flying machines, but as a stationary engine we cannot overlook the fact that this near relation of the gas engine is destined to do much useful work. Already it has been adapted with success, and eminent engine makers are providing types designed in frames suitable for the work, sometimes with attached dynamo in the event of electric power being required. The manufacturer is fortunate who is conveniently situated to a waterfall where he can utilise this cheapest of power. But Niagaras, even modest ones, are few and far between in this country.

Log Saws. The first machine that deserves notice is naturally that attacking the log and converting it into planks. A vertical log band saw effects this by means of an endless saw passing over pulleys, the timber being laid on a travelling metal table. The machine takes its name from the position in which the saw works. The latest method of treating with the log is by machines with horizontal band saws.

These log saws are continuous in their action, and the timber may be examined after each cut, that the man in charge may see if the next cut should be made as close as originally intended. Log saws are also arranged in sets whereby a log may be slabbed completely into planks or boards at one operation. It is well to remember that the thinner the saw blade the less the waste in conversion. The young timber student is often liable to forget allowance for saw cuts when, say, a 3 in. deal has to be cut up.

The Ordinary Band Saw. A coachbuilder must have a very small and unusual business not to warrant the adoption of an ordinary band saw. This tool is very useful for work with curved outlines, and can be fitted with an adjustable fence for straight work. For dealing with stuff on the bevel the table can be swung down to accommodate the angle of the work under treatment.

Another useful machine is the circular saw, which may be hand or machine fed. The fence may be removed for cross cutting when the capacity of the shop does not warrant a separate machine.

Circular saws are also fixed to the beams overhead as well as to the ordinary table. The former are known as pendulum saws. Fret saws are useful for cutting out internal work, a hole being drilled for the start.

Planing Machines. Planing machines are often more in evidence than is comfortable to the hearing. Yet when one sees a machine facing the four sides of a heavy piece of timber in a few minutes he is, perhaps, reconciled to its noise. Machine planing can be given a higher finish by passing the stuff through scraping machines, after which process little is necessary on the part of the bodymaker.

The various joints are quickly and accurately shaped on matchboarding, mortising, boring, and tenoning machines. The function of irregular moulding machines is to form rebates on pillars and rails, and mouldings of various shapes where required. Wood lathes are necessary for any work of a circular character. A very useful class of machinery is that set apart for the manufacture of wheel parts. Spokes are made and copied, stocks bored and mortised, felloes planed, and rims bent and dressed.

Metal-working Machines. The smith as well as the bodymaker has his mechanical appliances. His fire may be blown, his tyres bent, his work forged and upset- all without manual labour. In constructional steel work we should expect to see in the railway shops riveting and punching machines, a class of tool which is often operated by pneumatic power.

The Elevator. Although present practice does not favour many-storied factories for vehicular work, yet it is general to find an elevator or lift which carries up the body in the wood and iron to the paint shop, or brings down the finished vehicle ready to be sent away. The lift must be suited to the load it has to carry. Coachbuilders find that motor-cars, when being sent to the paint shop with châssis complete, need a more powerful lift than has hitherto been necessary. Travellers on the Central London Railway are familiar with the hydraulic and electric types, and there are also the older patterns coupled up to the factory steam engine or worked by hand.

Technical Education. The technology of vehicle building has received most attention in the road and rail carriage building departments, but during the last two or three years, van-building and wheelwrighting have been included in the syllabus of our large institutes. Evening classes are held during the winter months in such centres as Birmingham, Bristol, Newcastle, Liverpool, and Wolverhampton, while London, which lately had three classes in road carriage building, has now only one. At Stratford there is a large class in railway work, the natural outcome of the factory in the vicinity.

Official Examinations. The City and Guilds of London Institute recognise all these three subdivisions of the trade (road, rail, and van), and separate examinations are held annually, generally about May.

Vehicle Day School. London possesses the only English practical day school in vehicle work in the world, and although the evening classes are well appreciated, it is a great pity that the day school is not better supported by the trade.

The motor body is classified officially with the horse-drawn carriage, and as yet no separate syllabus has been in operation for the different principles governing automobile coachwork.

Literature of the Trade. Considering the importance to the community of vehicles generally, the scantiness of the textbooks available is surprising.

Rail carriage building is, however, well represented by the "Car Builders' Dictionary," 1903 ("Railroad Gazette," New York), price $5; "Railway Carriages and Waggons," by Stone; parts 1 and 2, 1905-6 ("Railway Engineer," Ludgate Circus, E.C.), 10s. 6d. each part. The "Locomotive Magazine," 2d. monthly, contains many useful articles on railway coachbuilding from time to time.

Road Carriage Books. There are many small textbooks and pamphlets published, but none can be considered manuals. Among the best are Philipson on "The Art of Coach Body Making" (John Kemp); Philipson on "Suspension of Carriages" ("Hub," New York), and "Coachbuilding" (Bell), by the same author; Thrupp on "History of Coaches" (Kerby & Endean); "Handbook for Coach Painters," by Simpson (Cooper); "Coach Trimming," by Farr & Thrupp (Chapman & Hall).

A useful collection of essays is the volume of papers read before the Institute of British Carriage Manufacturers (1883-1901), published by the Powage Press. The subjects embrace all departments of the trade.

As regards trade journals, we have the "Automobile and Carriage Builders' Journal" (16, Eldon Street, E.C.), 10s. per annum, and the "Coachbuilders' Art Journal" (64, Long Acre), 25s. per annum. Both are monthly periodicals, and embrace all departments, including automobile work and van-building.

Illustrations and general details of motor-car bodies are well set out in the numerous motor-car weeklies, such as the "Autocar," 3d., "Automotor," 3d.; "Motoring Illustrated," 1d.; "Motor Car Journal," 1d.; "The Car," 6d.; etc., but their actual province is, of course, motor engineering.

Cycles. Books on cycle construction include "Modern Cycles," by A. J. Wallis-Taylor, 10s. 6d. (Lockwood), "Cycling," by H. Graves, etc., 1s. (Suffolk Sporting Series), "Cycling" (Ward, Lock & Co., Ltd.), 1d., are useful little works on the popular pastime. Periodicals such as "Cycling" and the "Motor" (formerly "Motor Cycling") are representative of the periodicals.

Continued

PRACTICAL WEAVING

Drawing-in or Healding. Practical Points in Jacquard Tying. Making Cloth. Linen, Jute, and Silk Looms

Continued from page 3886

By W. S. MURPHY

HAVING acquired an understanding of the structure and fittings of the loom, we can now proceed to make use of it. The warp is healded before it is put on the loom; but the method of drawing is founded on both a knowledge of the loom and the plan of the designer. For every design there is a treading plan, or draft. The former term points to the treadles of the hand loom which direct the motions of the healds; the latter term applies to harness of all kinds—to the jacquard, the dobbie, the lappet, and other contrivances. It is by the management of the warp and its relation to the weft that the loom is patterned.

Plain cloth presents no problem: the treading plan is straightforward. Say that we have two healds. The weaving beam [**174**], with the warp on it, is slung, and the healds are hung before it. The healder's boy helper stands at the warp and feeds the threads in proper order. Through heald No. 1 the first, third, fifth, and all the odd-numbered threads are drawn; through heald No. 2, the second, fourth, and other even numbers are drawn. The healder has a tool like a long crocheting needle, with which he pulls through the threads at a rapid rate.

When one plain web succeeds another, the former warp leaves ends in the healds, and then the duty of the healder is to twist the ends of the new warp on to the threads of the old one. The trade designation of the old order of men who did the healding was *drawers and twisters*.

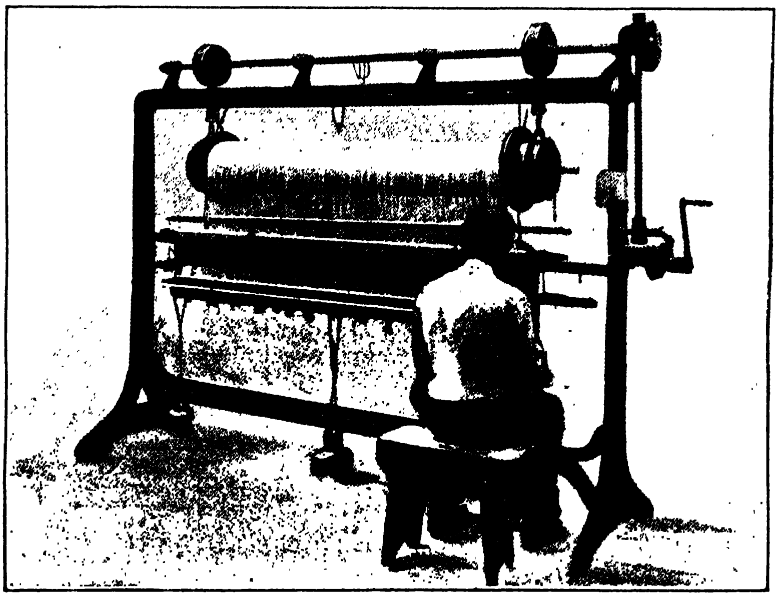
Treading Plan. It is when we take up twills and fancy weaves that the treading plan becomes important. For every change in the relation of warp and weft we must have a heald. The three-leaved twill, for instance, is only one remove from plain weaving, and is applied to sheetings, blankets, and other cloths of that nature. With the three leaves we can obtain only a single variation in the warp — two threads up and one down, one up and two down, alternately, though the weft may effect other variations.

Four-leaved twill begins complexity. With four healds we can make a fairly large variety of patterns, limited only by the general rule that "when two threads differ from each other in their order of weaving or interweaving at any point, they cannot be actuated by the same heald." Three threads over and one under the weft is cashmere; two under and two over gives a two-sided twill. We may reverse the order of the first, and vary in several other ways which are obvious.

Dimity and Diaper. Five leaves add still further to the resources of the designer. The simplest use of the five leaves is in the production of dimity, in which the weft passes over four warp threads and under one. Diaper alternates the action, four threads of warp and four threads of weft coming up in turn to the surface, with, of course, one intermediate thread.

With the five-leaved harness, the satin surface can be produced, and, in heavy cottons such as jeans, or woollens, is commonly adopted.

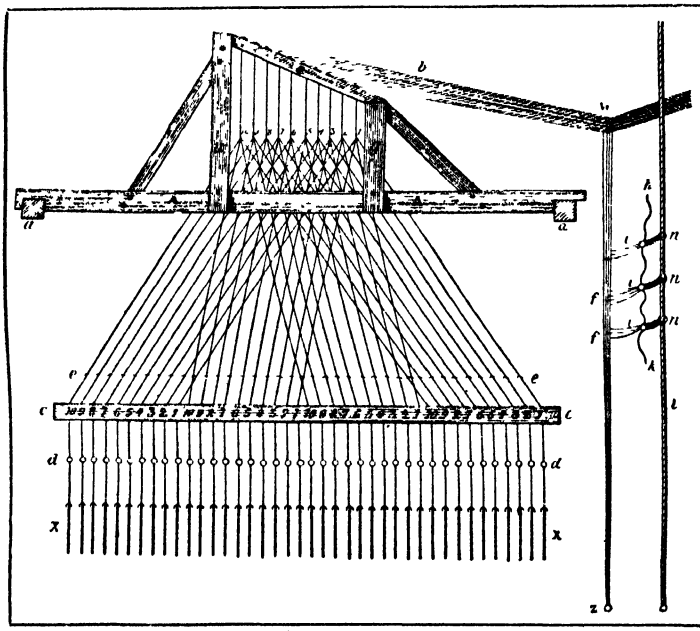
Numerous fine patterns are woven with the set of five healds; some weavers contend that the finest cloth effects require no more; but the numbers run up to eight, ten, twelve, and even sixteen in some fabrics. Silk weavers often



174. DRAWING-IN OR HEALDING (H. Bannerman & Sons, Ltd., Manchester)

prefer the large number of healds to any other form of harness. We think, however, that ten healds mark the limit where the use of healds ceases to be of any advantage over the jacquard and the dobbie in any circumstance, and highly skilled weavers even refuse to allow more than five where the jacquard can be brought into requisition. Into this debate we do not invite the student. Experience will enable him to form an opinion of his own.

Harness. Great as the French inventor was in genius, he did not originate a single important feature in the jacquard machine. Like Shakespeare, he took the material at hand, and put it into his idea. The jacquard, in short, is simply the old loom harness [175] made automatic. Detailed study of the harness would not be of much practical value, and we therefore note only those features it has in common with the jacquard to assist the student in understanding the operation of *tying*. A board (*c*) perforated throughout was hung over the loom, and through this the cords of the harness were passed to the number required, amounting in many cases to thousands. The cords (*c*) were looped to take up the warp threads, according to the design; these, again, were knotted together at the neck, and from each group a single cord passed through a series of pulleys across to a fixed piece of wood, called the *table* (*o*), and firmly fastened. From each cord (*w*) a cord was let down to a fixture in the floor (*f*), and at the side of these another stout cord (*l*) was fastened from floor to ceiling. Next, small cords called *lashes* (*i*) were bound in the order of the design from the harness cords to the fixed cord. The drawer pulled the first set of lashes tight, bringing out the proper vertical cord from the rest; these he pulled by themselves, and thus acted on the set of harness cords he designed to call into action, lifting the warp threads in the order the weaver required.



175. LOOM HARNESS

Tying up the Jacquard. The student has made acquaintance with the mechanism of the jacquard, and it now remains for us to inquire into the methods to be adopted in bringing it into practical use. In the old harness loom we had a certain freedom which is limited in the newer apparatus. We could put as many or as few cords as we liked into a row on the harness; but in the jacquard, because it is a machine applicable all round, the cords and needles corresponding must be definitely numbered. Jacquards are known as 300, 400, 500, or 600, according to the number of hooks they contain. The hooks are ranged in rows of 8 and 12, and each row must be complete; therefore a 300 jacquard contains either 304 or 308 hooks, just as the hooks are ranged in rows of 12 or 8. Suppose our pattern occupies 18 threads, what is to be done? The number 18 is not a multiple of 304. We must cast out, as the saying is, 16 hooks. This is not such a simple matter as may seem. We have to keep the whole web in due proportion; the vacancies must be so distributed as to leave no gaps in the warp. For the sake of simplifying the matter, let us suppose that we are working with healds. If our healds give 60 threads of warp to the inch, and we find it impracticable to give more than 50 threads to the inch, our plan would be to miss one loop in 30 in the heald of 300 cords. Similarly, in our jacquard we must reduce the number of threads per inch in the warp if the pattern does not come out even with the number of hooks on the machine. In designing we have this to consider and provide for. Should it be necessary to put a large number of threads into the inch, the process must be reversed, and the extent of pattern woven at each revolution, or the total use of all the hooks, reduced. At this point we sight the vast range of problems which the designer deliberately faces when he undertakes to work with the jacquard.

Cards. The cards are the most valuable idea in the jacquard apparatus. By means of these the work of tying-up is simplified. Making the cards is a mechanical operation. From the designer the card cutter gets the design, marked on pointed paper to correspond with the hooks of the jacquard. On each line those squares are marked

black, which shows that a warp thread is to be lifted. Perforations are cut in the card corresponding to the black squares on each line. Automatic machines have now been invented which do all but read the design, and cut the perforations with an accuracy the most skilful workman could hardly hope to equal. When the cards are cut, they are sewn together by another machine, modelled on the common sewing machine.

The cards are folded together and set on the cylinder, a few slips requiring to be let out for the purpose. Considerable variation occurs at this point, some sheaves of cards being arranged so that they merely fall over from one position to another, while others make a wide circle, as many as twenty cards flying loose like a slack belt. This and other minor details signify little to the student.

Now let us see the connection of warp and jacquard. Every cord has a small weight at the end and an eyelet where the warp passes through. To each warp thread there is a cord, and we draw the threads through in the same way as has been done on the healds. The cords pass through what is called the *cumber board*, and those which belong to the same hooks—that is, those attached to warp threads interweaving in one way throughout the pattern—are joined, and from them single threads pass up to the hooks of the jacquard.

In dealing with this wonderful machine we have tried to keep strictly to the side of simplicity. Into the manifold uses of the jacquard we cannot enter. At the present day every textile industry utilises the jacquard in one form or another. Understanding of the machine takes us a considerable way towards making intelligent use of it, whether as weaver or designer, as managers or workers. If the student could always remember that the jacquard is little more than an aggregation of healds, and think of each neck cord as a heald cord, he would not be led astray by the seeming complexity of the contrivance.

Making Cloth. Having examined the main parts of the loom, let us try to obtain a clear view of its general working in the weaving-shed [176]. The shedding of the warp, the crossing of the weft, and the beating of the reed in the slay, are the principal actions of the loom, and we can look at them in order. At the moment when the reed comes up against the cloth, the loom is in balance, and ready for another operation. The slay swings back, and the parts begin to act. The tappets, or the jacquard, shed the warp, opening it till the slay has reached the centre of its stroke. Then the shuttle comes flying through. The warp closes, while the slay comes forward, and, before the shed is shut, drives home the weft.

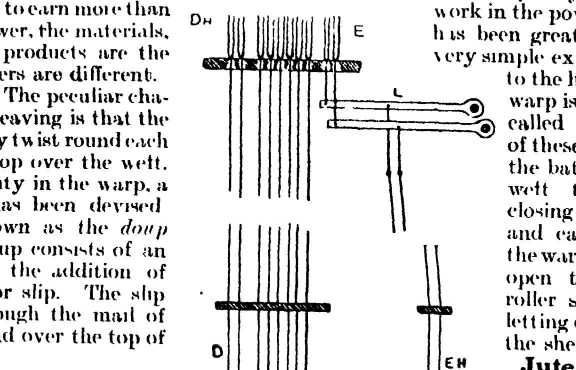
All the other parts move in harmony with these, being governed more or less directly by them. It is in the adjustment of part to part that the harmony of the loom is obtained, and a good cloth woven. The shuttle must be directed

176. A SHEETING WEAVING-SHED (Horrockses, Crewdson & Co., Ltd., Preston)

by picker and spindle, so that it will fly straight, and the reed must be in direct line with the shuttle-box. The adjustment of the warp calls for the closest attention. While the under half of the shed should lie level on the shuttle race to give the shuttle a free flight, the least pressure on the race will alter the balance of the tension and cause slackness. The taking-up motion needs to be watched, for the least variation in the leverage alters the whole character of the cloth. On looms with numerous mountings the duties of the overlooker and weaver are correspondingly increased. We have developed the loom to a high degree, and made it almost automatic, as we have seen in the Northrop loom; but human skill and attention can by no means be dispensed with The weaver is the cloth maker still. Broken picks, flakes, twists, and other faults may occur in any web if the weaver is not careful; even with the greatest care they do occur, and must be neatly and quickly repaired. To get a fine skin on the cloth is the supreme object of the satin weaver; but the weaver of the coarsest jute should not be unmindful of the same. A perusal of the wages-book of any weaving factory would startle many who lightly think of the weaving craft. Some weavers earn an average of 29s. per week, where others, working under exactly equal conditions, fail to earn more than 14s. The driving power, the materials, the looms, and the products are the same; but the weavers are different.

177. DOUP HEALD

Gauze Loom. The peculiar characteristic of gauze weaving is that the warp threads partially twist round each other, and form a loop over the weft. To obtain this mobility in the warp, a special mechanism has been devised This is what is known as the *doup* heald [176]. The doup consists of an ordinary heald, with the addition of another half heald, or slip. The slip may either pass through the mail of the ordinary heald and over the top of it, or it may pass entirely through it. In the latter case, the slip is held in position by the thread of warp passing through it; in the former case, the heald remains in position at all times. The purpose of the doup is to raise the warp threads so as to produce a twist. For illustration, suppose that we are working strips of alternate gauze and plain cloth. Two common healds are required, and the warp is drawn through them in the usual manner. The doup heald is placed in front, and one thread of each pair crossed under the other and passed through the slip of the doup. In weaving plain cloth, the loose slip rises and falls into harmony with the other healds, to avoid changing the position of the warp threads passed through it, the main part of the doup heald remaining stationary. But when gauze is to be made the whole doup heald lifts, bringing the thread it carries to the contrary side of its neighbour, and forming a crossing which the passage of the weft renders permanent. One difficulty in this operation has always troubled weavers, and that is the sudden pull of the doup heald; lifting the threads it carries above the ordinary tension causes many breaks if not otherwise prevented. Slackeners of various kinds have been invented. The one thing to be demanded from any slackener is that it should act only with the doup heald and let the slack back when the need for it has ceased. In the diagram [178] the whole action of the warp (W) is shown. The heald (D) carrying the doup (S) appears in its proper relation to the slackener heald (E H). The rest of the mechanism drawn has already been described.



178. GAUZE HEALDS
(From Ashenhurst's "Practical Weaving")

Linen Loom. The looms used in linen manufacture are almost identical with those of the cotton-weaver. In the linen weaving shed there are plain looms, looms equipped with the jacquard and dobby fittings, and many looms of great weight. One feature, however, is special to the linen loom, and that is the slackening beam. In spite of every device, linen remains a hard thread, with little elasticity, and the lack of that quality makes it difficult to work in the power loom. The defect has been greatly minimised by a very simple expedient. On its way to the heddles, or healds, the warp is passed over what are called *carrier beams*. One of these is lifted by a cam as the batten drives home the weft thread between the closing shed of the warp, and calls up the slack of the warp. When the healds open the shed again the roller sinks into its place, letting out the warp to form the shed.

Jute and Silk Looms. The jute loom has about it no special features; its size alone marks it out from all other textile weaving machines.

In no textile trade is there such a variety of looms used as in the silk industry. In country villages, in the very heart of London, we find silk woven on hand looms with and without jacquard apparatus. In the great centres of silk manufacture, such as Coventry and Macclesfield, we find the fine adaptations of all the highest forms of loom. The lappet, the swivel, the jacquard, and all the other fancy devices are utilised. The student of silk may not omit the study of any form of weaving machine.

Continued

THE PROGRESSIONS

Arithmetical, Geometrical, and Harmonical Progressions. Insertion of Means between Two Given Quantities. Summation of Series

continued from page 3896

By HERBERT J. ALLPORT, M.A.

ARITHMETICAL PROGRESSION

143. If we have a series of quantities such that the difference between any one of them and the preceding one is the same throughout the series, the quantities are said to be in *Arithmetical Progression.*

We shall use the letters A.P. as an abbreviation for Arithmetical Progression.

Examples.

(i.) 1, 4, 7, 10 .... are in A.P.
(ii.) 5, 3, 1, -1........... are in A.P.
(iii.) a, $a+d$, $a+2d$....... are in A.P.

The difference between each term and the preceding term is called the *common difference.* In the first of the given series, by subtracting any term from the term which follows it, we see that the common difference is 3; in the second series it is -2; in the third series it is d.

144. Series (iii.) in the last Article represents the *general* form of an A.P. The coefficient of d in the different terms should be noticed. Thus, in the 2nd term the coefficient of d is 1; in the 3rd term it is 2; in the 4th term it is 3, so that *the coefficient of* d *is always less by unity than the number of the term.* Hence, in the nth term, the coefficient will be $(n-1)$, and the nth term $= a + (n-1)d$.

Therefore, we can write down *any* term of an A.P. when we know the first term and the common difference.

Example. The 24th term of the series whose first term is 17 and common difference -3, is $17 + (24-1)(-3)$, or $17 - 69$, *i.e.*, -52.

145. When *any* two terms of an A.P. are known, any other term of the series can be found.

Example. The 8th term of an A.P. is 25 and the 21st term is 51. Find the 3rd term.

Let $a =$ the 1st term, $d =$ the common difference. Then,

$$\text{the 8th term} = a + 7d = 25, \quad . \quad . \quad (1)$$
$$\text{the 21st term} = a + 20d = 51. \quad . \quad . \quad (2)$$

Solving the equations (1) and (2) we find $a = 11$, $d = 2$. Hence,

$$\text{the 3rd term} = a + 2d$$
$$= 11 + 4 = 15 \ \underline{\textit{Ans.}}$$

146. If three quantities are in A.P., the middle one is called the *Arithmetic Mean* between the other two.

The arithmetic mean between two given quantities, a and b, is easily found. For, if x be the required mean, a, x, b are in A.P., so that $x-a$ and $b-x$ are each equal to the common difference. Hence,

$$x - a = b - x,$$

from which we obtain

$$x = \frac{a+b}{2}.$$

Thus, *the arithmetic mean of two quantities is half their sum.*

147. In a similar way, if we have any number of quantities in A.P., the intermediate terms are called arithmetic means between the first and last. An example will make clear the method of inserting any required number of means between two given quantities.

Example. Insert 4 arithmetic means between 7 and -8.

Having inserted 4 means between 7 and -8, we shall then have *six* terms in A.P. We have, therefore, to find the common difference of a series in which the 6th term is -8 and the 1st term is 7.

Let d be the common difference. Then,

$$-8 = 7 + 5d \ [\text{Art. } \mathbf{144}];$$

therefore,

$$d = -3.$$

The series is therefore 7, 4, 1, -2, -5, -8.

148. *To find the sum of any number of terms of an A.P.*

Let $a =$ the first term, $d =$ the common difference, and $l =$ the last term. Clearly the term before the last will be $(l-d)$, and the next preceding one will be $(l-2d)$. Suppose we are required to find the sum of n terms. We cannot write down *every* term of the series, since we do not know the actual values of a, d, and n; but writing a few of the terms at each end of the series we have, if s be the required sum,

$$s = a + (a+d) + (a+2d) + \ldots + (l-2d) + (l-d) + l.$$

Writing the series in reverse order we get

$$s = l + (l-d) + (l-2d) + \ldots + (a+2d) + (a+d) + a.$$

Hence, adding corresponding terms,

$$2s = (a+l) + (a+l) + (a+l) + \ldots \text{to } n \text{ terms},$$
$$= n(a+l).$$

Therefore,

$$s = \frac{n}{2}(a+l). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now,

$$a + l = a + a + (n-1)d \ [\text{Art. } \mathbf{144}],$$
$$= 2a + (n-1)d.$$

Hence,

$$s = \frac{n}{2}\{2a + (n-1)d\}. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Of these two formulæ (2) is perhaps more useful than (1), but both should be remembered.

Example 1. Sum the series 1, 3, 5, 7, 9 ... to 20 terms.

Here $a = 1$, $d = 2$, $n = 20$.
Therefore,

$$s = \frac{20}{2}\{2 + (19 \times 2)\}$$
$$= 10 \times 40 = 400 \quad \underline{Ans.}$$

Example 2. How many terms of the series 28, 24, 20 ... must be taken in order that their sum may be 88?

Let n be the required number of terms. The common difference of the series is

$$24 - 28 = -4.$$

Hence, using formula (2) of the present article, we have

$$88 = \frac{n}{2}\{56 - 4(n-1)\},$$

or, on simplification,

$$n^2 - 15n + 44 = 0.$$

The solution of this equation gives

$$n = 4 \text{ or } n = 11.$$

Hence, the sum of 4 terms or of 11 terms will be 88.

NOTE. Where *two* values of n satisfy the question, the sum of the extra terms in the second case is zero. This is easily seen by writing down 11 terms of the given series, *viz.*, 28, 24, 20, 16, 12, 8, 4, 0, -4, -8, -12. Evidently the sum of the last 7 terms is zero, so that the sum of 4 terms is the same as the sum of 4 + 7, or 11 terms.

GEOMETRICAL PROGRESSION

149. A series of quantities is in *Geometrical Progression* when the ratio of any term to the preceding term is the same throughout the series. This ratio is called the *common ratio* of the series.

Examples.

(i.) 2, 4, 8, 16 ... is a G.P. whose common ratio is 2.

(ii.) $\frac{1}{3}, -\frac{1}{6}, \frac{1}{12}, -\frac{1}{24}$ ... is a G.P. whose common ratio is $-\frac{1}{2}$.

(iii.) a, ar, ar^2, ar^3 ... is a G.P. whose common ratio is r.

150. In the series whose 1st term is a and common ratio r, the 2nd term is ar, the 3rd term is ar^2, the 4th term is ar^3, and so on, *the index of r always being less by unity than the number of the term.* Thus, the *general term*, or nth term, of the series is ar^{n-1}. Hence we can write down *any* term of a G.P. when we know the first term and the common ratio.

151. When any *two* terms of a G.P. are known, the series itself is easily found.

Example. Find the 2nd term of a G.P. whose 4th term is -2 and whose 7th term is $\frac{1}{4}$.

Let a be the 1st term and r the common ratio of the series. Then (Art. **150**) the 4th term is ar^3 and the 7th term is ar^6.

Hence,

$$ar^3 = -2 \quad . \quad . \quad . \quad . \quad . \quad (i),$$

and

$$ar^6 = \frac{1}{4} \quad . \quad . \quad . \quad . \quad (ii).$$

Dividing the second equation by the first we have $r^3 = -\frac{1}{8}$, and therefore $r = -\frac{1}{2}$. Substituting in (i) we get $a = 16$. Hence, the required 2nd term

$$= ar$$
$$= 16 \times \left(-\frac{1}{2}\right) = -8. \quad \underline{Ans.}$$

152. When three quantities are in G.P. the middle one is called the *geometric mean* between the other two.

Suppose a, b, c are in G.P. Then,

$$\frac{b}{a} = \frac{c}{b},$$

since each of these ratios is the common ratio of the series.

Therefore, $\quad b^2 = ac,$

or $\quad b = \sqrt{ac}.$

Hence, *the geometric mean between two quantities is the square root of their product.*

153. When any number of terms are in G.P. the intermediate terms are called *geometric means* between the first and last terms.

Example. Insert 3 geometric means between 6 and 96. We have here to find the series of 5 terms (consisting of 6, 96, and the three means), of which the 1st term is 6, and the 5th 96.

Let r be the common ratio. Then, since the 5th term of the general series is ar^4, we have

$$6r^4 = 96.$$

Therefore, $\quad r^4 = 16;$

therefore, $\quad r = \pm 2.$

The series is therefore 6, ± 12, 24, ± 48, 96, and the required means are ± 12, 24, ± 48.

154. Sum of n Terms of a G.P.

Let a be the 1st term, r the common ratio. Then the nth term is ar^{n-1}, the $(n-1)$th term is ar^{n-2}, and so on. Hence, if s be the required sum, we have

$$s = a + ar + ar^2 + \ldots + ar^{n-2} + ar^{n-1}.$$

Multiply both sides of this equation by r, putting the terms of the right-hand side one place to the right. Then,

$$rs = \quad ar + ar^2 + \ldots + ar^{n-2} + ar^{n-1} + ar^n.$$

Subtract corresponding sides of the two equations.

Therefore, $\quad s(1-r) = a - ar^n;$

therefore, $\quad s = \dfrac{a(1-r^n)}{1-r}.$

Example. Sum the series 1, 3, 9 ... to 6 terms. In this case $a = 1$, $r = 3$, $n = 6$.
Therefore,

$$s = \frac{1-3^6}{1-3} = \frac{3^6-1}{2} = \frac{728}{2} = 364. \quad \underline{Ans.}$$

155. Sum of an Infinite Number of Terms of a G.P. When the common ratio of a G.P. is less than unity, there is a limit to the value of the sum of its terms; that is, we cannot make the sum as great as we please by taking a very large number of terms. For example, suppose we have a line 3 in. long. First take away half the line, then take away half the remainder, then half of the new

remainder, and so on. The lengths of the parts taken away will be $\frac{3}{2}$, $\frac{3}{4}$, $\frac{3}{8}$, $\frac{3}{16}$, etc. Now, the sum of the parts taken away can evidently never be greater than 3 in.; also, since the remainder diminishes indefinitely as the number of parts taken away is indefinitely increased, the sum of the parts taken away can be made to differ from 3 in. by an indefinitely small length. Hence, the sum of an infinite number of terms (or, the *sum to infinity*) of the series $\frac{3}{2}$, $\frac{3}{4}$, $\frac{3}{8}$ ... is 3.

The formula for the sum to infinity is deduced from that of Art. **154**.

$$s = \frac{a(1-r^n)}{1-r}$$
$$= \frac{a}{1-r} - \frac{ar^n}{1-r}.$$

Now, when r is less than unity, numerically (whether it be + or −), the numerical value of r^n decreases as n is made larger, and can be made as small as we please by sufficiently increasing the value of n. Hence, s can be made to differ from $\frac{a}{1-r}$ by as small a quantity as we please.

The sum of an infinite number of terms of the series a, ar, ar^2 ... is therefore $\frac{a}{1-r}$.

It must be particularly noted that the "sum to infinity" can only be found in cases where r is less than unity.

HARMONICAL PROGRESSION

156. A series of quantities is in *Harmonical Progression* if, when any three consecutive terms are chosen, the difference between the first and second is to the difference between the second and third as the first is to the third.

Thus, a, b, c, d ... are in H.P. if

$$a-b : b-c :: a : c.$$
$$b-c : c-d :: b : d,$$

and so on, for every three consecutive terms.

157. A more easily remembered definition is the following: *Quantities are said to be in H.P. when their reciprocals are in A.P.* This relation is easily deduced from the definition of the last article. For, if a, b, c are in H.P., we have

$$\frac{a-b}{b-c} = \frac{a}{c}.$$

Therefore, $\quad ac - bc = ab - ac.$

Divide both sides by abc. Then,

$$\frac{1}{b} - \frac{1}{a} = \frac{1}{c} - \frac{1}{b},$$

which shows that $\frac{1}{a}$, $\frac{1}{b}$, $\frac{1}{c}$ are in Arithmetical Progression.

158. When three quantities are in H.P., the middle one is the *harmonic mean* between the other two.

If a, b, c, are in H.P., we have proved that $\frac{1}{a}$, $\frac{1}{b}$, $\frac{1}{c}$, are in A.P., and therefore,

$$\frac{2}{b} = \frac{1}{a} + \frac{1}{c} \text{ [Art. } \mathbf{146}\text{].}$$

Hence, $\quad b = \frac{2ac}{a+c}.$

159. *The geometric mean of two quantities is the geometric mean between their arithmetic mean and their harmonic mean.*

Let a, b, be the two quantities, and A, G, H, their arithmetic, geometric, and harmonic means, respectively.

Then, $\quad A = \frac{a+b}{2}$ [Art. **146**],

$G = \sqrt{ab}$ [Art. **152**],

$H = \frac{2ab}{a+b}$ [Art. **158**];

therefore,

$$A \times H = \frac{a+b}{2} \times \frac{2ab}{a+b} = ab = G^2,$$

or $\quad G = \sqrt{AH},$

so that G is the geometric mean between A and H.

160. No general formula can be found for obtaining the sum of **a** number of terms in H.P.

Many questions in H.P. are solved by considering the corresponding problem in A.P.

Example. Insert 3 harmonic means between 1 and 3.

We insert 3 *arithmetic* means between 1 and $\frac{1}{3}$. Their reciprocals will be the required harmonic means.

As in Art. **147**, we find the arithmetic means are $\frac{5}{6}$, $\frac{2}{3}$, $\frac{1}{2}$. Hence, the required harmonic means are $\frac{6}{5}$, $\frac{3}{2}$, 2.

EXAMPLES 34

1. The 3rd term of an A.P. is 72 and the 8th term is 37. Find the 1st term.

2 Insert 4 arithmetic means between 2 and 17.

3. The sum of the 1st and 2nd terms of a G.P. is 10, and the sum of the 3rd and 4th terms is 160. Find the 5th term.

4 Sum the following series:

(i.) $3 + 6 + 9 + \ldots$ to 15 terms.

(ii.) $6 + 5\frac{1}{2} + 5 + \ldots$ to 20 terms.

(iii.) $\frac{1}{3} + \frac{3}{4} + \frac{3}{2} + \ldots$ to 5 terms.

(iv.) $1 + \frac{1}{\sqrt{3}} + \frac{1}{3} + \ldots$ to infinity.

Continued

Continued from page 3683

SINGLE ENTRY & ROYALTIES

Profit and Loss Account by Single Entry. Hire Purchase Accounts. Interest. Mining Royalties. Chartered and Incorporated Accountants

By J. F. G. PRICE

LITTLE has been said hitherto upon the subject of keeping books by what is known as single entry. The reason has been that no accountant would recommend the keeping of books by these means in a business of any size. Having regard to the fact, however, that there are many small traders who do keep their books in this way, it is necessary that some description of the process should be given. The great drawback of the method is the impossibility of proving the accuracy of the records kept under it.

Single Entry Methods. The books in use vary in different businesses, but usually there are a cash book and a ledger; sometimes there is a day book. What semblance of a system there is in keeping books by this method consists in entering in the cash book all cash received, from whatever source, and all cash paid away, for whatever purpose, and in keeping accounts in the ledger for customers owing money to the business. Sometimes the ledger contains also the accounts of wholesale dealers from whom goods have been purchased on credit. The "system" is usually a mixture of double entry and single so far as the practice observed in keeping the books is concerned. No goods account is kept, and the only way in which purchases and sales are recorded is on the cash and personal accounts. When a cash sale is made the cash received is merely entered on the debit side of the cash book, but no posting is made to the ledger. This is mere single entry, there being a debit entry, but no corresponding credit.

Ledger Entries. In a sale on credit the customer's account in the ledger is debited, but there is no credit to a goods or sales account. This is single entry. But when cash is received from a debtor in respect of goods previously sold on credit with which he has been debited, the amount received is not only entered on the debit side of the cash book, it is posted to the credit of the customer's account. This is complete double entry. Similarly, when payments are made for cash purchases the payments are recorded on the credit side of the cash book, but are not posted to a ledger account. Further, cash paid for rent, wages, and other expenses of the business, although entered on the credit side of the cash book, are not posted to nominal accounts in the ledger. Where no ledger accounts are kept for creditors the same principle is applied, and payments made to persons who have supplied goods on credit are not posted to the ledger. But where ledger accounts have been opened for persons who have supplied goods on credit the payments to them are posted to their debit, as well as being entered on the credit side of the cash book. This, of course, is again complete double entry. There is thus very little system about single-entry bookkeeping, and this failing is particularly felt when a trader desires to know the result of his operations at the end of a year's transactions. To meet his wishes in this respect a means has to be devised for arriving at the desired result with some degree of accuracy; but although errors of magnitude can be avoided by the exercise of common-sense, it is not possible to place absolute reliance upon the result obtained.

Single Entry Profit and Loss. The first step to be taken is to dissect the cash book. Taking the debit side, the receipts will probably be found to consist entirely of cash sales and receipts from debtors on credit sales. There may be also some items in respect of further capital introduced by the proprietor. The credit side will consist of payments for cash purchases, to persons for credit purchases, rent, wages, rates, carriage and miscellaneous trade expenses. There will be also the proprietor's drawings, and these must be carefully inquired into, for money is frequently withdrawn from a business by the proprietor without a record of the fact. The ledger accounts must then be analysed to ascertain the amount of the credit sales, which will consist of the posting of goods to the debit of the personal accounts. These can be approximately checked by comparing the total of the entries with the cash received from debtors during the year plus the debts outstanding. After providing for any discounts or other allowances made to debtors, the two totals should agree. The same course must be pursued with the credit purchases, and a similar comparison made.

The value of the stocks at the beginning and end of the period will be required, and if these are obtainable a trading and profit and loss account can be prepared. There is, as a rule, no difficulty in obtaining the stock at the close, but that at the beginning is not usually so readily procurable unless it is a new business. The initial stock is generally the most uncertain element in the accounts prepared on this plan, and if it was not taken in a proper manner at the beginning of the trading period it must be estimated.

Inasmuch as the whole result will depend upon the estimate formed, it must be very carefully made, and the usual means adopted is to take the closing stock at cost, add to this the total sales, less a percentage for gross profit, and then deduct the purchases. Here,

of course, everything depends upon the trustworthiness of the percentage of gross profit, and if any other means are available the result should be tested by them. Care must be taken to ascertain if there are any outstanding liabilities not recorded in the books, in respect of rent, rates, wages, or other expenses, as these may materially affect the result. Having taken the above steps, a profit and loss account and balance-sheet can be prepared in the usual form.

Conversion to Double Entry. The trader, after the trouble he will have experienced in obtaining these results, will probably desire to revise his methods of keeping his accounts in the future. If so, the first steps to be taken will be to bring into use purchases and sales books for the recording of all goods bought and sold on credit. The periodical posting of these books and the cash book into the ledger, together with the opening of a goods account and the various nominal accounts, will make his books capable of proof, and the results of accounts showing his trading operations thoroughly reliable.

If he decide to keep his books on double-entry principles in future, all that need be done to record in his books the position shown in the balance-sheet is to open ledger accounts for his stock, for his capital, and for the creditors if there are not accounts for them already. This having been done and the purchases and sales books brought into operation, the record of his transactions will proceed upon ordinary double-entry lines.

Hire - purchase Accounts. Many businesses are now conducted upon the instalment plan—*i.e.*, they sell their goods upon the terms that they may be paid for by the purchasers gradually by periodical payments. When this is the case, the price at which the goods are sold is naturally higher than that at which they would have been sold for cash. This increased price is due to the fact that the seller does not receive the purchase price at once, but only a small portion of it, and he, therefore, charges interest on the part unpaid. It is this factor of interest that occasions the necessity of keeping the accounts of such businesses—known as *hire-purchase accounts*—on special lines.

Formal agreements are entered into when sales of this nature take place, and for the protection of the seller they generally treat the transaction as one for the hire of the goods, which are to be made over to the hirer at the end of a stated period (provided the instalments are regularly paid), either without further payment or upon payment of a trifling amount. But, although the agreements usually treat the transaction as one of hire, it would not be correct for the seller to treat the periodical payments he receives as income which he is entitled to take to credit in full in his profit and loss account and yet at the same time treat the goods as his property, although in the hands of another. He must deal with the matter on the basis of a sale. But he must not take credit for the full amount charged to the purchaser, since that price includes interest which is only accruing due over a more or less lengthened period.

Manufacturer's Books. Business is conducted on these lines in connection with railway waggons, house furniture, pianofortes, cycles, etc., all over the kingdom, and it was principally in relation to railway waggons that accounts were first specially designed to meet the facts of this particular class of transaction. To take the case of the manufacturer first, it will be necessary for him to have his sales book ruled with two money columns—one for principal, the other for interest. When a sale is made on the hire-purchase system the manufacturer knows how much of the total price is for interest, and he enters the amounts in the two columns accordingly. The total price will be debited to the customer, the sales account will be credited with the amount of the principal or cash price, and the interest account with the balance.

The sold ledger will be ruled with two columns on each side—one for principal, the other for interest. A note will be made at the head of each customer's account as to the manner in which the price is to be paid. The debit to the customer will be divided into principal and interest, and the two amounts entered in the appropriate columns. As he pays the instalments cash will be debited and he will be credited with the full amount, the proportion attributable to principal being entered in the principal column and that to interest in the other column. The earlier instalments will, of course, include a greater proportion of interest than the later, owing to there being a large amount of principal outstanding upon which interest has to be charged.

When the manufacturer is making up his accounts at the close of a trading period, he must not take credit for the full amount of interest which has, during the period, been credited to the interest account, as sales were effected. Although interest has been charged to the hirers or purchasers it has not all been earned, and a rebate, or allowance, must therefore be made in respect of interest charged on the various purchasers' accounts, but which has not yet accrued due.

He should also make provision for the fact that if some of the goods were returned by the purchasers they would probably not be worth the amount at which they stand to the debit of the various customers' accounts. In some businesses this might not be so after a few payments had been made, but the manufacturer must, after taking all the circumstances into consideration, make such allowance as is in his opinion sufficient under this head. In order that the student may follow the working of this system the specimen of a customer's account in a manufacturer's ledger is given on the next page.

Hirer's Books. The matter has now to be considered from the view of the hirer or purchaser. When the agreement is entered into he does not credit the manufacturer with the full amount of the purchase price, as the latter becomes a creditor only when the instalments fall due. The method adopted, therefore, is to

Agreement No. 1,853. W. BROWN 36 Monthly Payments of £3,

Dr.		Interest.	Principal.		*Cr.*	Interest.	Principal.
1906. Jan. 1	To Sales Account		90 0 0	1906. Jan. 1	By Cash ..	0 15 0	2 5 0
	" Interest "	18 0 0		Feb. 2	" "	0 14 2	2 5 10
				Mar. 2	" "	0 13 4	2 6 8
				April 3	" "	0 12 5	2 7 7
				May 2	" "	0 11 6	2 8 6
				June 1	" "	0 10 7	2 9 5
						14 3 0	75 17 0
		£18 0 0	90 0 0			£18 0 0	90 0 0
1906. July 1	To Balance ..	£14 3 0	75 17 0				

debit an account opened for the article purchased —waggons, furniture, or as the case may be, with each instalment as it becomes due, and credit the manufacturer. When the instalment is paid the manufacturer is debited and cash credited. The result is that, provided the instalments are paid promptly, there is no balance on the manufacturer's account, as the credit of the instalment is immediately extinguished by the debit of cash. As the price of the goods, as we have seen, includes a considerable sum for interest, care must be taken to ensure that the articles purchased are included in the annual balance-sheet at not more than their actual value. This value will be the portion of the price which has been paid in respect of the principal amount due, irrespective of interest.

The purchaser must ascertain how much of the price payable under the agreement is for interest. He can generally obtain the information from the manufacturer, or can arrive at it by finding out the cash price as compared with that which he is paying. The difference will, of course, be interest, of which, as already stated, the larger proportion will fall against the earlier years. At balancing-time an adjustment must be made by debiting the interest apportionable to the year to the profit and loss account and crediting the account of the articles purchased, which will thus stand at their cash price in the books.

Depreciation. In addition, provision must be made for the depreciation of the articles, and the allowance calculated, not upon the portion of the price actually paid, but upon the full cash price. This depreciation is put through the books in the ordinary way by debiting depreciation account and crediting the asset account with the amount written off. The net result of these entries will be that the asset will stand in the books at the end of the period over which the payments have been spread at its actual value to its owner.

This method of dealing with articles bought on the hire-purchase system is obviously only necessary in the case of a trader who has made a purchase of considerable value by these means. The ordinary man who has bought a cycle or pianoforte by instalments does not keep an account at all, but it is of the utmost importance in the case of an hotel-keeper who has purchased a large quantity of furniture on the system, or a colliery proprietor who has bought a number of waggons. Unless both these individuals take steps to show the articles they have purchased at their cash value only they will be overstating their profits, since they will not be debiting the profit and loss account with the interest on what is in effect borrowed money for the purchase of the articles.

ROYALTIES

A *royalty* is an amount paid by a person for the right to use the property of another. Thus the lessee of a mine pays a royalty to the owners of the land on which the mine is situated; a theatrical manager pays a royalty to a dramatic author for the right to produce his play; a manufacturer to a patentee for the right to use his patent, and so on. The amount paid in respect of the royalty depends upon the extent of the use which is enjoyed by the lessee or concessionaire in each case. A rate is usually fixed per unit. In the case of a colliery it is either upon the tonnage output or the superficial or cubic area worked. In the case of a patent it will depend upon the number of articles produced, in the manufacture of which the patent has been used; and in the case of a play, it depends upon the number of performances.

It will be seen, therefore, that the amount paid in respect of a royalty is as much an expense of the particular business paying it as the rent, salaries, and other working expenses. It must be treated in the same way as the other expenses and debited to the profit and loss account. As the amount depends upon the extent of the user, a careful record must be kept, which must be available for inspection by the owner of the property, showing the output or production as the case may be. The form which the record will take must depend upon the nature of the property for the use of which the royalty is paid. In the case of a colliery, if the royalty is upon tonnage, the amount recorded in the pit books and agreed by the workmen's check weigher will be accepted by the landlord; while if it is upon area it will be fixed by survey. In most cases, when once the amount payable has been agreed, the entries to be made in the books of the business having the use of the property are simply a debit to the profit and loss account under the head of royalties, and a credit to the owner. When he is paid he is debited and cash credited, and this will close the matter until the next periodical payment becomes due.

Mining Royalties. But in the case of a colliery a slight complication frequently arises. The form which the concession usually takes is

a lease of the land for the purpose of working the mining rights subject to the payment of a minimum annual sum. An amount of royalty is also fixed, which we will assume is payable upon the amount of coal raised. The fixed minimum is usually known as *dead rent.* If it exceeds the royalty upon the coal raised in a particular year, then nothing beyond the dead rent is payable; but if, on the contrary, the royalty exceeds the dead rent, the latter becomes merged in the royalty and only the royalty on the tonnage is paid.

Redeemable Dead Rents. There is often a further provision in the lease that payments of dead rents in excess of royalties may be recovered by deduction from future royalties when these exceed the dead rent in a particular year. But the operation of this right is usually limited as to the time within which it may be exercised. The time limit is frequently five years. Thus, unless by the end of the fifth year the royalties exceed the dead rents, any excess dead rent on the first year will become irrecoverable, while if that state of things continued for another year, the excess on the second year would be lost to the lessee. So long as the right of recovery exists, the excess of dead rent paid is carried forward as an asset, the only charge to the profit and loss account in respect of the sum payable under the lease being the royalty on the coal actually raised. But so soon as the period has gone by within which it could have been deducted from excess royalties, it must be written off to profit and loss.

The working of the following example will show the student how the redeemable dead rent and the royalty accounts are dealt with in the books of the person working the colliery: A lease of a colliery is granted at a minimum dead rent of £600 per annum, merging into a royalty of 1s. per ton, with a right to recover dead rents out of royalties paid within five years. The quantity of coal raised was 800 tons the first year, 4,600 tons the second year, and 75,000 tons the third year.

It will be observed that the amount received by the landlord for the three years—*viz.*, £4,020 —is the amount of the royalty on actual output.

Investigation and Audit. Our method in dealing with the subject has necessarily been to describe the process of recording transactions of different kinds in the books of an undertaking. The organisation of accounts on such a basis as to facilitate the keeping of the financial records of the business, and to give the proprietor of the concern the information he requires in the best possible way, is an important branch of the accountant's profession, but one not less so is that dealing with the investigation of accounts, including their audit. The business man is well advised who leaves investigation and audit to a skilled accountant, for no man who has not been specially trained to the work can be regarded as a reliable investigator and auditor of accounts. There are two societies of professional accountants in England and Wales—*viz.*, the Institute of Chartered Accountants, which confines its operations to the countries named, and the Society of Accountants and Auditors, which has branches in other parts of the world. The members of the former body

Dr. REDEEMABLE DEAD RENT ACCOUNT *Cr.*

1903.			1903.		
Dec. 31	To Landlord . ..	600 0 0	Dec. 31	By Royalty on 800 tons	40 0 0
				,, Balance c/d. ..	560 0 0
		600 0 0			600 0 0
1904.			1904.		
Jan. 1	To Balance b/d. ..	560 0 0	Dec. 31	By Royalty on 4,600 tons	230 0 0
Dec. 31	,, Landlord . ..	600 0 0		,, Balance c/d. ..	930 0 0
		1,160 0 0			1,160 0 0
1905.			1905.		
Jan. 1	To Balance b/d. ..	£930 0 0	Dec. 31	By Landlord	£930 0 0

ROYALTY ACCOUNT

1903.			1903.		
Dec. 31	To Dead Rent A/c. ..	40 0 0	Dec. 31	By Profit and Loss A/c.	40 0 0
1904.			1904.		
Dec. 31	,, Dead Rent A/c. ..	230 0 0	Dec. 31	,, Profit and Loss A/c.	230 0 0
1905.			1905.		
Dec. 31	,, Landlord	£3,750 0 0	Dec. 31	,, Profit and Loss A/c.	£3,750 0 0

LANDLORD

1903.			1903.		
Dec. 31	To Cash	600 0 0	Dec. 31	By Dead Rent	600 0 0
1904.			1904.		
Dec. 31	,, Cash	600 0 0	Dec. 31	,, Dead Rent	600 0 0
1905.			1905.		
Dec. 31	,, Dead Rent Recoverable	930 0 0	Dec. 31	,, Royalty on 75,000 tons	3,750 0 0
	,, Cash	2,820 0 0			
		£3,750 0 0			£3,750 0 0

are known as chartered accountants, those of the latter as incorporated accountants. The chartered institute dates from 1880, the incorporated society from 1885, and both have large memberships. It will be seen from the dates mentioned that, as compared with medicine and the law, the organisation of the profession of accountancy is comparatively young; but it should be mentioned that societies of earlier foundation were merged in the institute on its formation, and, of course, the practice of accounting in a more or less primitive state dates back to the early ages. There are accountants' societies in Scotland and Ireland, the former being older than the English bodies.

Professional Accountants. The conditions for admission to membership of the various societies are practically the same, the principle rule being that intending members must serve five years' articles of apprenticeship to a practising member. During the period under articles the would-be accountant is learning his business in its various aspects, a considerable portion of his time in the earlier years being occupied in acting as junior clerk on audits. In the later years he is, naturally, doing more important work, and gradually acquiring a knowledge of the different branches of his profession. He is required to pass a preliminary examination before admission to articles, and during his service he has to pass an intermediate examination. At the expiration of his articles he presents himself for his final examination, and if he satisfies the examiners is admitted to full membership of his society. The subjects of examination are, of course, those of which a knowledge is required by the accountant in his profession. They are set out in full on pages 148 and 149.

The proper training and examination of a body of men capable of investigating the financial books of a concern, with a view to ascertaining the accuracy or otherwise of the records in them, is a work of immense value to the commercial community generally, having regard to the dependence which has to be placed upon such records.

Merchants and others are not slow to avail themselves of the opportunity afforded them of checking the work of their employees by means of the audit of their accounts conducted by a professional accountant.

The class of work upon which incorporated and chartered accountants are largely employed is the audit of the accounts of private concerns and limited companies. The reason of the non-discovery of many of the frauds which have been exposed of recent years, particularly in connection with the accounts of Friendly Societies, has been the failure to employ professional men as auditors. Reliance has, instead, been placed upon the well-meant but quite incompetent examination of the accounts conducted by men who, in some cases, were quite ignorant of the first principles of bookkeeping. This condition of things still exists to a large extent, although matters are improving.

From what has been said, it will be apparent that, although certain principles and rules might be laid down in connection with the investigation of accounts for the guidance of the ordinary business man who wishes to know that his bookkeeping arrangements are satisfactory, or for the young clerk who desires to be more than a recording machine, it is not possible to give in the shape of an article the knowledge that is required to make the practical auditor and complete accountant. Something can be done in that direction, but the only satisfactory course for the beginner is to enter the office of a chartered or incorporated accountant, and go through the whole routine necessary to fully qualify himself; while for the business man engaged in his own affairs all the year round the only safe course is to employ a properly qualified accountant to safeguard his interests by auditing his books periodically.

Work of a Professional Accountant. Professional accountants, in addition to their work as auditors, are largely engaged in examining into and reporting upon the accounts of businesses which it is proposed to convert into limited companies. This function, to which reference was made in the article on company work, is of the utmost importance, as the public probably place more reliance upon the certificate of the accountant as to the past working of the concern than upon any other statement in a prospectus. They are further extensively employed as trustees in bankruptcies and under deeds of arrangement, as liquidators in the winding up of companies, and as receivers of properties on behalf of mortgagees and debenture holders. In any of these capacities they may be required to carry on a business for a more or less extended period, or their duties may be confined to the realisation of the property to the best advantage, and the distribution of the proceeds amongst the persons entitled.

From this brief summary of some of the more important duties of the professional accountant the reader will see that a training in the office of an incorporated or a chartered accountant with a varied practice affords a splendid opportunity of becoming familiar with the working of all kinds of businesses. This fact is of considerable value, for many young accountants, after serving their articles, seek positions as secretaries, managers and accountants of important companies and public bodies, and their prospects of success are greatly enhanced if they hold the diploma of one of the recognised societies.

Clerkship concluded

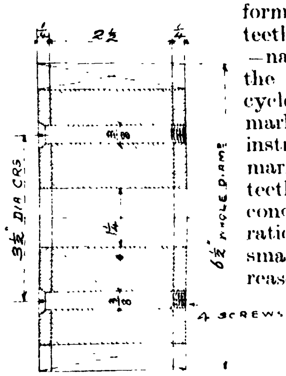
FORMS OF GEARING

Raw-hide Gears. Mortise Teeth, Helical Gears. Internal Gears, Racks, Bevels and Mitres. Screw Gears, Worms and Worm Wheels

TECHNICAL DRAWING continued from page 3800

By JOSEPH W. HORNER

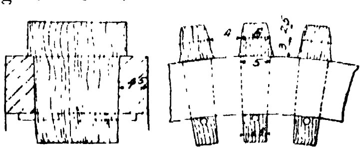
Raw-hide Gears. Pinions which run at high speeds, such as those on electric motor spindles, are frequently made of raw hide. Discs of ox hide are cemented together in layers under pressure in order to form the rough blank, which is then machined all over to finished sizes; side plates—usually of gunmetal—are fitted as shown in section **104**, and the teeth are cut through the hide and through the metal plates. Sometimes one of the side plates has cast with it a bush, which passes through the pinion and forms a stronger driving medium for the key than can be afforded by the hide and plates alone. Wheels have been made of raw hide up to 3 ft. diameter, the rim being of hide and the arms and boss of cast iron. Such wheels are, however, unusual, it being the more common practice to make pinions only of hide and the wheels with which they gear of metal. The object in using raw hide is to ensure noiseless running.



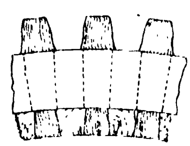
24 TEETH 4 DP 6" PITCH DIA

104. RAW-HIDE PINION

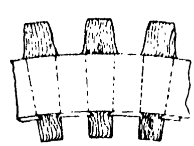
Mortise Teeth. Another and an older device to ensure a quiet running gear is to make the wheel teeth of wood; such teeth are termed *cogs*, are made separately by hand labour, and are fitted into slots cast in the wheel rim. Fig. **105** shows a good method of securing the teeth as well as the proportions for tooth and wheel rim; the figures given are to be multiplied by the circular pitch in order to obtain actual dimensions. Mortise wheels are used in flour mills, cotton mills, etc. The cogs are made of well-seasoned oak, acacia, hornbeam, or apple-tree, and the grain must run in a radial sense as shown in the illustration [**105**]. Instead of holding the teeth by means of pins, wooden wedges, as **106**, or steel plates, as **107**, may be used, and pins are used where the arms occur, as in **108**. This class of gear is expensive, and is gradually falling into disfavour.



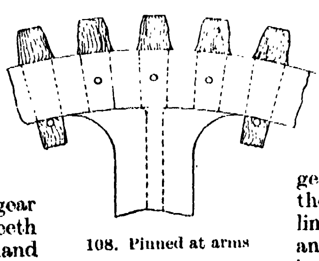
105. Pinned



106. Wedged



107. Plated



108. Pinned at arms

105-8. MORTISE TEETH

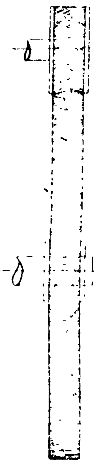
Helical Teeth. A quiet gear drive is obtained by making the teeth short lengths of a right and left hand screw or helix, as shown in **109**; the theory of construction is based upon an almost obsolete form of gear termed *stepped gear*, where the width of the teeth is divided into a number of equal parts and each part is moved slightly in advance of its fellow. The merging of these steps into a straight line gives a helical curve to the tooth; it is necessary to make it right and left, or *double helical*, as it is termed, in order to avoid end thrust on the shafts. These gears are usually cast, but can be machine-cut. They are used largely for rolling-mill engines where reversal under load occurs. The usual angle for the teeth is 30 deg. measured from a horizontal line parallel with the shaft.

Internal Gears. These gears are made by forming the teeth upon the inside of the wheel rim as indicated in **110**. The principle of tooth formation is the same as for outside teeth, but the spaces become the teeth—namely, the tooth curve is reversed; the odontograph can be used for cycloidal teeth, but the face curve is marked from the flank data on the instrument, while the flank curve is marked from the face data. If involute teeth be struck, then the curve becomes concave instead of convex. When the ratio of wheel and pinion becomes very small, difficulties are encountered by reason of the teeth fouling each other. Normally, there should be at least a difference of 15 teeth between wheel and pinion. Internal gears are used on lathe headstocks, revolving gears on cranes, and so forth, or in cases in which both driving and driven shaft must rotate in the same direction.

Rack. A rack is a straight line of teeth as **111**. It is used to produce rectilinear motion from rotary motion, or vice versâ; it is applied to the tables of planing machines, the operation of sluice-doors, and so forth. The teeth may be marked out with the odontograph for cycloidal curves. If a rack be required to gear with an involute pinion, then the face and flank become a straight line drawn at right angles to the angle of obliquity, as in **111**. A rack is in effect part of a circle of infinite

diameter; the circumference of a circle approaches a straight line as the diameter increases, and when the diameter is infinite any part of the circumference is a straight line. Cycloidal curves are formed by the rolling of generating circles upon a straight line as well as upon a curved line, but an involute struck from a straight line becomes a straight line.

Bevel Gears. We have hitherto only dealt with gears having their teeth formed upon parallel surfaces; bevel gears have their teeth formed upon conical surfaces, and are used for connecting shafts which are not parallel. Fig. **112** gives three views of a pair of conical cylinders in contact, having their axes at right angles and intersecting at O; considering the lines of contact A, B, and C as pitch lines, ordinary cycloidal or involute teeth may be formed upon them; the pitch circle, the pitch, and the section of tooth are reduced from the "major" diameter D to the "minor" diameter E, following radial lines to O. A section of a pair of bevels is given in **113**, together with the method of marking out the teeth at the major and minor diameters. Draw the axes or shaft centre lines, O A and O B, intersecting at O, then the major diameters C and D, then the pitch lines extending to O; mark off the width of the tooth E, and its depth and clearance; the major diameter is counted as the true pitch diameter, and the ordinary proportions of teeth, etc., apply there; the width of the tooth may be taken as the same as in spur gears. Lines are now drawn at right angles to the pitch lines of the teeth and extended to F and G and to H and J; arcs are then struck from F and G, the outer arc in each case being the developed pitch circle at the major diameter, and upon which the teeth are marked out as in spur gears, the inner arc being the developed pitch circle at the minor diameter. The radius of the inner arc for the bevel wheel is taken from H K, and is transferred to F L; radial lines are then drawn from the outer arc to centre, F, and upon these lines the pitch and the tooth section diminish regularly. The corresponding depth of tooth is taken by compasses from the minor diameter in the sectional view. The development of the teeth on the inner arc of the pinion is dealt with in the same manner as for the wheel.

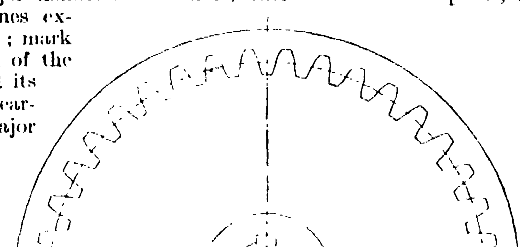


109. HELICAL-TOOTHED SPUR GEAR

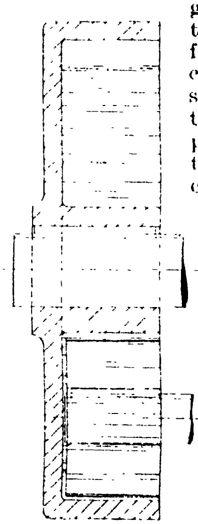
When bevel gears are made with equal diameter wheels they are termed *mitre gears* from the fact that the pitch lines make an angle of 45 deg. with the axes of the shafts. Bevel gears may be made with axes at other than right angles; if the angle be greater than 90 deg. they are frequently termed *angle spur gears.*

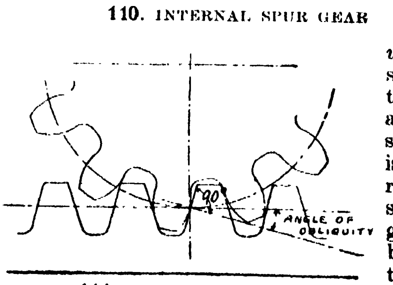
The thickness of the rims of bevel gears is made about ·56 of the pitch at the major diameter and decreases radially to the minor diameter. The arms are usually made **T** section, as in **114**, and to the proportions given for cross arms for spur wheels. The strength of a bevel tooth is calculated at the mean pitch. Bevel gears may be half shrouded or fully shrouded, and they may be made with helical teeth or with mortise teeth or of rawhide.

Screw Gears. When the axes of wheels gearing together are not in the same plane, recourse is had to *screw* or *spiral* gears. The teeth are formed upon cylindrical surfaces, but they are not parallel with the axes of the cylinders; each tooth is a portion of a spiral thread or helix. A screw wheel may have any number of such teeth from one upwards; a one-toothed screw wheel is termed a *worm,* and corresponds to a single-thread screw; a many-toothed wheel corresponds to a multiple-thread screw. The section of these screw threads is a standard tooth form, generally the involute. Fig. **115** shows a pair of screw wheels gearing together, their axis being at right angles. The screw threads on both wheels are the same hand; the number of



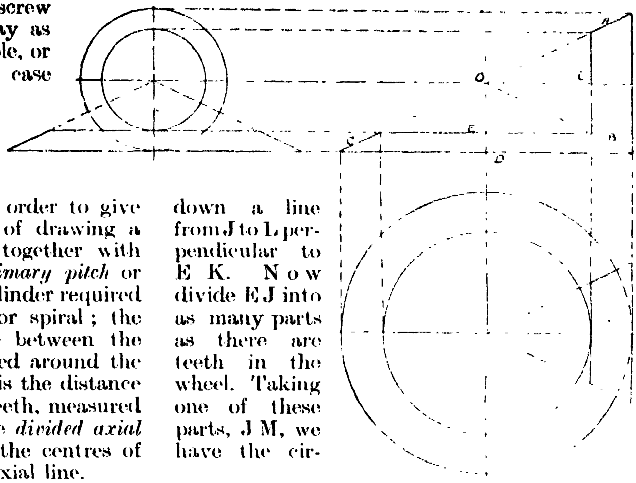
110. INTERNAL SPUR GEAR





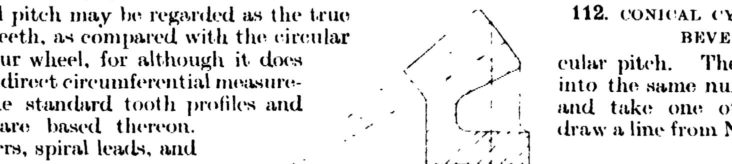
111. RACK AND PINION

teeth is counted as the number of screw threads involved, in the same way as we would speak of a double, triple, or quadruple thread screw. In the case illustrated there are 12 threads, or teeth, in each wheel; they will, therefore, transmit motion at equal velocities. But such gears can be made with different diameters and numbers of teeth, in order to give different velocities. The method of drawing a screw wheel is shown in **116**, together with explanatory projections. The *primary pitch* or *lead of spiral*, A, is the length of cylinder required to complete a turn of the screw or spiral; the *circular pitch*, B, is the distance between the centres of adjacent teeth measured around the circumference; the *normal pitch* is the distance between the centres of adjacent teeth, measured at right angles to the spiral; the *divided axial pitch*, C, is the distance between the centres of adjacent teeth measured on the axial line.

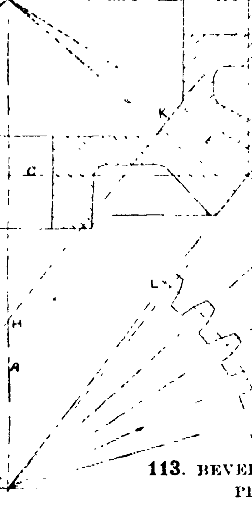


112. CONICAL CYLINDERS FOR BEVELS

The normal pitch may be regarded as the true pitch of the teeth, as compared with the circular pitch of a spur wheel, for although it does not represent direct circumferential measurement, yet the standard tooth profiles and proportions are based thereon. Pitch diameters, spiral leads, and circular pitches may vary in any two wheels in gear, but the normal pitch must be constant, otherwise they will not work together. In order to set out a screw wheel it is convenient to start with the circular pitch, and this is readily obtained from the normal pitch by means of the diagram in **116**. Draw a horizontal line, A′ B′, and extend a line, A′ C′, representing the tooth angle, and draw a line normal to this and of a length equal to the normal pitch, D′ E′; then A′ D′ equals the circular pitch. When the axes of the shafts intersect at right angles, as in **115**, it is essential that the sum of the respective tooth angles be 90 deg., and it is, of course, convenient to make each one 45 deg.

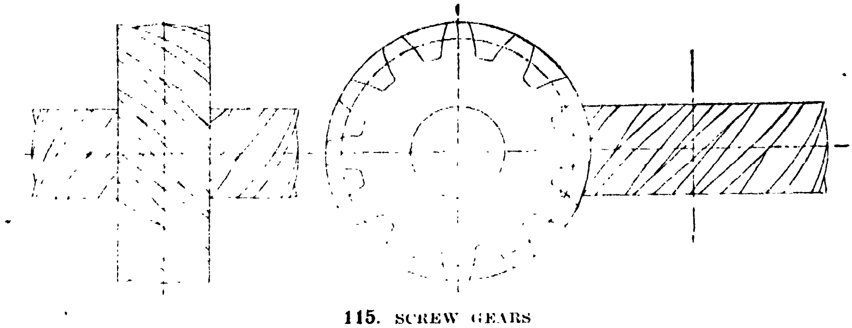


113. BEVEL WHEEL AND PINION



114. BEVEL WHEEL (ARM SECTION)

Delineating the Spiral. Having obtained the circular pitch, calculate the pitch diameter, as in the case of spur gears, and draw the pitch circle, D in face elevation [**116**], and also in side elevation E F G H, which latter may be termed the *pitch cylinder*. Unroll this cylinder until the length, E J, represents its circumference, and then draw the diagonal, E K, which is the developed spiral, and lay down a line from J to L perpendicular to E K. Now divide E J into as many parts as there are teeth in the wheel. Taking one of these parts, J M, we have the circular pitch. Then divide J K into the same number of parts and take one of them, J N; draw a line from N to M, cutting J L at O, and then J O is the normal pitch, and J N is the divided axial pitch. The next step is to develop the end elevation of the teeth in order to draw the face view. To do this it is first necessary to ascertain the diameter of the normal pitch circle, and this must be measured in the same plane as the normal pitch. Upon the line E J, mark off a distance, E P, equal to the radius of the pitch cylinder, and draw a horizontal line, P R, cutting E K at R; then lay down a line, R G, perpendicular to E K, and E G is the radius of the normal pitch circle. To develop the teeth, transfer the radius, E G, to the lower left hand view [**116**], and upon it mark out involute teeth of the pitch required, as in ordinary spur gears. Selecting a tooth whose centre line coincides with the angle of the spiral, we project its various thicknesses upon a vertical line, S T, and reproject them upon a horizontal line, U V, the depth of the tooth remaining the same



115. SCREW GEARS

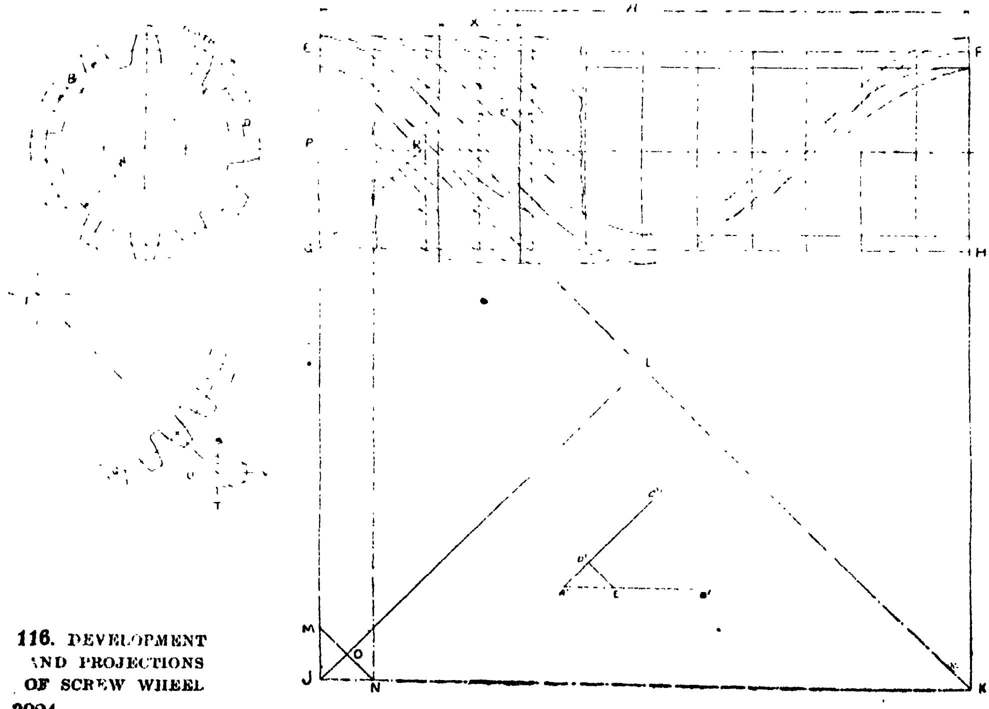
points so obtained. A slice may be taken from the cylinder of projected spirals, as X, and this slice is the screw wheel required. The width, X, should be sufficient to ensure at least one pair of teeth being well in contact before the next pair leave contact. This is attained if the width be made to contain a pitch and a half measured circumferentially, as shown in the face elevation.

in each case. We may now transfer the tooth developed on line U V to the face elevation of the wheel. The teeth and the spaces look abnormally wide, but this is, of course, due to the fact that they are not perpendicular to the face of the wheel.

The pitch line is now projected upon the cylinder in the same manner as we projected the helix and the screw thread on page 3003. A tooth may be also projected in a similar way by considering it to be coiled on a cylinder of a diameter equal to that of the wheel measured under the teeth, as W. There is no necessity to draw the complete helix in actual practice, but it is shown so in 116 in order to present the principle in as clear a manner as possible. Further teeth may be drawn without the labour of projecting each one. Make a tracing of one half helix, and move it successively one axial pitch, pricking off the tooth points in turn; the tooth curves may then be drawn through the points so obtained. A slice may be taken from the cylinder of projected spirals, as X, and this slice is the screw wheel required. The width, X, should be sufficient to ensure at least one pair of teeth being well in contact before the next pair leave contact. This is attained if the width be made to contain a pitch and a half measured circumferentially, as shown in the face elevation.

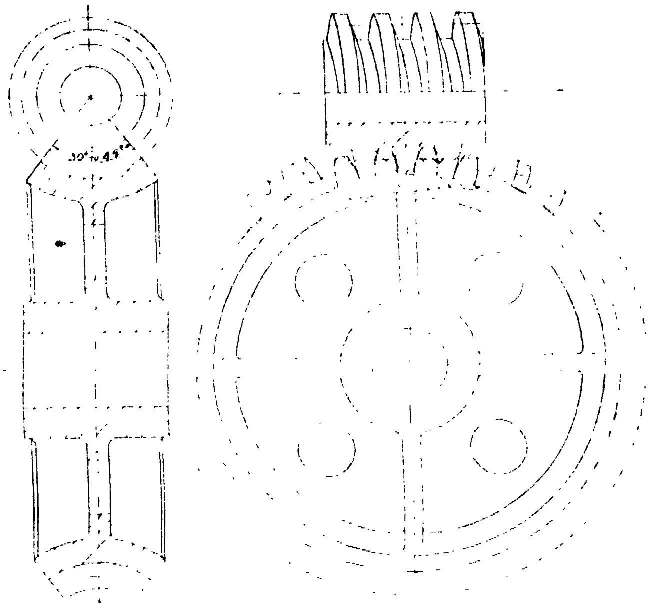
Screw gears may be made with their axes at various angles, and with wheels of various diameters; the teeth of helical gears, as mentioned earlier in this lesson, are portions of similar spirals.

The Worm and Wheel. This is a true screw gear, with axes usually, though not necessarily, at right angles [117]. The worm may be single thread or multiple thread, the wheel containing many portions of internal threads, formed on an external surface. The sections of the threads are involute teeth, those of the worm having straight faces and flanks similar to a rack. The projection of the worm presents no difficulty, since it is a true spiral. The number of threads on the worm affects the speed of the worm wheel in direct ratio—that is to say, a single, double,



116. DEVELOPMENT AND PROJECTIONS OF SCREW WHEEL

or triple thread worm driving a wheel having, say, 33 teeth, would have to make 33, 16½, and 11 revolutions respectively to each revolution of the wheel. Worm gears are generally used for the purpose of speed reduction on account of the great difference obtainable in a small space. Fig. **118** shows a typical example of a worm gear reduction in an oil-tight case. The worm wheel itself has a phosphor bronze rim, out of which the teeth are cut, this rim being fitted tightly on to a cast-iron centre, and secured thereon by means of four set screws, spaced circumferentially. The worm is of mild steel, triple thread, left hand; the wheel has 60 teeth. The worm shaft is coupled to an electric motor spindle running at 500 revolutions per minute, and the speed of the worm wheel shaft is therefore $\frac{500 \times 3}{60} = 25$ revolutions per minute. The casing is of cast iron, and has a circular bracket cast on as shown, in order to support it. This bracket may be arranged in any position desired to suit the application of the gear reduction—that is, it may be cast underneath or on one side, if necessary. The casing forms an oil bath for the gear to run in, and the worm should preferably be arranged underneath the wheel, so as to ensure plenty of oil getting at the working teeth. Ball bearings are fitted to the worm spindle to reduce the friction due to the end thrust of the worm, these bearings being carried in a gland-shaped casting, which enables them to be removed bodily with the worm. It will be noticed that the worm is solid with the spindle, which

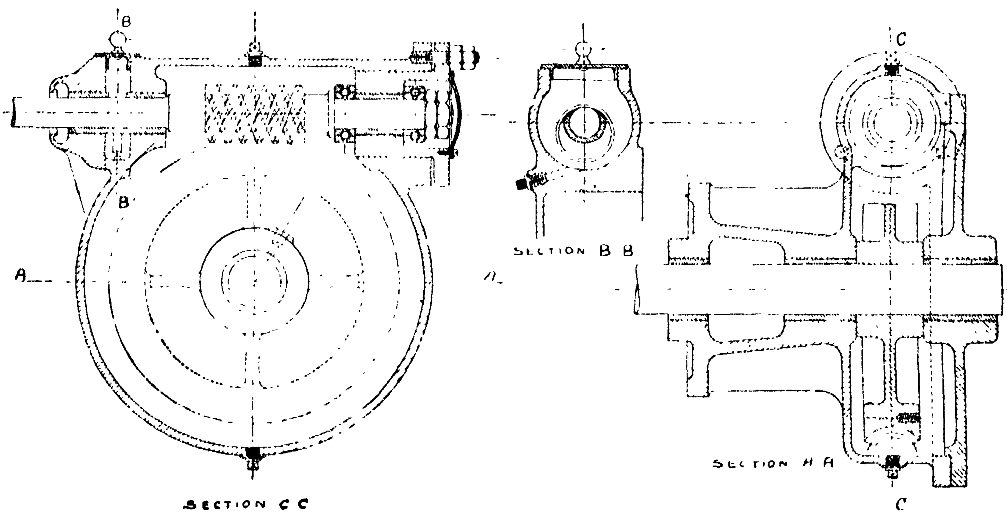


117. WORM AND WORM WHEEL

is usual with small worms, as there would not be sufficient metal left under the threads if they were bored out for the reception of the spindle. A small oil bath is also arranged for the worm spindle, and an oiling ring rests on the spindle and dips into the oil; this is a common device adopted to secure the proper lubrication of high-speed shafts in connection with motors and dynamos, etc.

The diameter of a worm is generally from three to five times the circular pitch, and the angle of engagement which determines the width of a worm wheel is usually 30 deg. to 45 deg., as indicated in **117**.

Continued



118. WORM GEAR AND CASING

Continued from page 3792

ITALIAN—FRENCH—GERMAN—SPANISH

Italian by F. de Feo; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten; Spanish by Amalia de Alberti and H. S. Duncan

ITALIAN

Continued from page 3787

By Francesco de Feo

VERBS—Third Conjugation—continued

SECOND CLASS

Finire, to finish

INDICATIVE MOOD

Present

I finish, etc.	We finish, etc.
finisco	*finiamo*
finisci	*finite*
finisce	*finìscono*

Past Indefinite

I have finished, etc.	We have finished, etc.
ho finito	*abbiamo finito*
hai finito	*avete finito*
ha finito	*hanno finito*

Imperfect

I finished, etc.	We finished, etc.
finivo	*finivamo*
finivi	*finivate*
finiva	*finìvano*

First Pluperfect

I had finished, etc.	We had finished, etc.
avevo finito	*avevamo finito*
avevi finito	*avevate finito*
aveva finito	*avèvano finito*

Past Definite

I finished, etc.	We finished, etc.
finii	*finimmo*
finisti	*finiste*
finì	*finìrono*

Second Pluperfect

I had finished, etc	We had finished, etc.
ebbi finito	*avemmo finito*
avesti finito	*aveste finito*
ebbe finito	*èbbero finito*

Future

I shall finish, etc.	We shall finish, etc.
finirò	*finiremo*
finirai	*finirete*
finirà	*finiranno*

Future Perfect

I shall have finished, etc.	We shall have finished, etc.
avrò finito	*avremo finito*
avrai finito	*avrete finito*
avrà finito	*avranno finito*

IMPERATIVE MOOD

Present

Finish, etc.	Let us finish, etc.
—	*finiamo*
finisci	*finite*
finisca	*finìscano*

SUBJUNCTIVE MOOD

Present

That I finish, etc.	That we finish, etc.
finisca	*finiamo*
finisca	*finiate*
finisca	*finìscano*

Perfect

That I have finished, etc.	That we have finished, etc.
àbbia finito	*abbiamo finito*
àbbia finito	*abbiate finito*
àbbia finito	*àbbiano finito*

Imperfect

If I finished, etc.	If we finished, etc.
finissi	*finìssimo*
finissi	*finiste*
finisse	*finìssero*

Pluperfect

If I had finished, etc.	If we had finished, etc.
avessi finito	*avèssimo finito*
avessi finito	*aveste finito*
avesse finito	*avèssero finito*

CONDITIONAL MOOD

Present

I should finish, etc.	We should finish, etc.
finirei	*finiremmo*
finiresti	*finireste*
finirebbe	*finirèbbero*

Perfect

I should have finished, etc.	We should have finished, etc.
avrei finito	*avremmo finito*
avresti finito	*avreste finito*
avrebbe finito	*avrèbbero finito*

INFINITIVE MOOD

Present—finire, to finish
Perfect—aver finito, to have finished
Past Participle—finito, -a, -i, -e, finished

1. The majority of the verbs of the third conjugation are conjugated like *finire* (second class), as:

capire (*cahpeèreh*), to understand
asserire (*ahssehreè-reh*), to assert
ardire (*ahrdeè-reh*), to dare
contribuire (*contreeboo-eèreh*), to contribute
preferire (*prehfehreè-reh*) to prefer
proibire (*pro-eebeè-reh*), to prohibit, to forbid
punire (*pooneè-reh*), to punish
spedire (*speh-deèreh*), to forward, to dispatch
unire (*ooneè-reh*), to unite
differire (*deeffehreè-reh*), to differ, etc.

2. The following verbs are conjugated like *vestire* (first class).

avvertire (*ahvvehrteè-reh*), to advise
bollire (*bolleè-reh*), to boil
convertire (*convehrteè-reh*), to convert
divertire (*deevehrteè-reh*), to amuse
dormire (*dormeè-reh*), to sleep
fuggire (*foodgeè-reh*), to escape
invertire (*eenvehrteè-reh*), to invert
partire (*pahrteè-reh*), to start
seguire (*sehgueè-reh*), to follow
sentire (*sehnteè-reh*), to feel
servire (*sehrveè-reh*), to serve
tossire (*tosseè-reh*), *to cough*

3. The following verbs may be conjugated either with or without the addition of the syllable *isc* (third class):

aborrire (*ahborreè-reh*), to abhor
applaudire (*ahpplah-oodeè-reh*), to applaud
assorbire (*ahssorbeè-reh*), to absorb
inghiottire (*eenkee-ötteè-reh*), to swallow
languire (*lahngu-eèreh*), to languish
mentire (*mehnteè-reh*), to lie
nutrire (*nootreè-reh*), to feed
pervertire (*pehrvehrteè-reh*), to pervert

The verbs *partire* and *divertire* may also be conjugated like *finire*, but then assume a different meaning: *parto*, I start; *partisco*, I divide in parts, I portion out; *diverto*, I amuse; *divertisco*, I cause to diverge.

NOTE: Besides the verbs of the first and third classes mentioned above, there are only a few others, which will be given among the irregular verbs.

OBSERVATIONS.

1. By no means all the verbs of the third conjugation have a present participle (termination *-nte*). Some of the verbs having the present participle retain the characteristic vowel *i* before the termination, as: *nutriente*, *ubbidiente*. The present participle of *sentire* is *senziente*; of *patire*, *paziente*; of *venire*, *vegnente*. The verb *dormire* has *dormente* and *dormiente*; *morire*, *morente* and *moriente*.

2. In ordinary conversation, the third person singular, preceded by *si*, may be used instead of the first person plural, particularly in the Past Definite and in the Present Conditional, as: *noi si comandò* for *noi comandammo*; *noi si crederebbe* for *noi crederemmo*.

3. The first person singular of the Imperfect of the Indicative may also have a termination *va*, but the form in *vo* is more common.

CONVERSAZIONE.

Finalmente! Credevo che non venissi più. Son due ore che t'aspetto. Perchè così tardi?

Mi dispiace di èssere in ritardo, ma degli affari importanti mi hanno impedito di venir prima.

Ebbene (*well*), l'hai veduto? Gli hai parlato?

Gli ho parlato, ma ne so meno di prima. Egli non ha voluto dir tutto, ma pare che àbbia intenzione di seguire l'esèmpio del suo compagno e partire anche lui per l'Amèrica.

Credi che riuscirà a far niente?

Io non credo; Giorgio è un giòvane troppo leggiero; avrebbe bisogno di un amico sincero che lo guidasse, che gli desse dei consigli . . .

Gli scriverò io e lo pregherò di venire da me. Gli darò io dei consigli che accetterà di tutto cuore, vedrai.

Hai ragione; Giorgio in questo momento ha più bisogno di danari che di consigli.

EXERCISE XXIX.

1. Parlate più lentamente, per piacere, perchè non vi capisco. 2. Non lo chiamate ancòra, lasciate che finisca di scrìvere. 3. Fate silènzio, vi proibìsco di parlár male di un amico in mia presenza. 4. Quale preferite di questi due? 5. Preferisco il primo, perchè è più a buon mercato. 6. Se egli lo asserisce, vuol dire (it means) che è vero. 7. Quella pòvera bambina non fa che (*does nothing but*) tossire tutto il giorno. 8. Avete dormito bene questa notte? 9. Questo tè non è buono; vi avete versato l'acqua prima che bollisse. 10. Dite alla domèstica di vestire i ragazzi, perchè è ora di andare. 11. Se gli artisti canteranno bene, li applaudiremo. 12. È già la terza volta che mi domandate se è vero; vi avverto che io non mentisco mai. 13. Non dite questo, vi prego, perchè avete mentito tante volte, che non credo più a quello che dite. 14. Le uova e la carne sono molto nutrienti. 15. Non capisco perchè vogliate avèr sempre ragione voi.

KEY TO EXERCISE XXV.

1. We shall meet them. 2. They will give us. 3. They sent (to) him. 4. What did he tell you? 5. What did you answer him? 6. Where are the flowers that we have gathered? 7. I have put them in water. 8. As soon as I see him I will speak to him of you. 9. I have seen him from the window, and I have called loudly to him twice, but he has not heard me. 10. Mary told us that she would have gone to Italy this year. 11. They have bought heaps of books; they have read them and re-read them, but I am sure that they have not understood anything in them.

KEY TO EXERCISE XXVI.

1. How much did you pay for those gloves? 2. I have paid rather dearly for them, but they are of an excellent quality. 3. Did you find them at home? 4. Her, yes; but not him. 5. When will you give me what you have so many times promised me? 6. If you give me some toys I will be good. 7. Have you any more writing paper? I wish to write to my bookseller to send me the books that I have ordered of him. 8. I am sorry; I have no more. I have given you all the paper that I had left. 9. No matter; I will write to him later.

KEY TO EXERCISE XXVII.

1. We shall receive. 2. Have you drunk? 3. If we lost. 4. They feared. 5. They would not have believed. 6. Would you have sold? 7. We would sell. 8. We sold. 9. Has he received? 10. I have not yet received, but I shall receive. 11. He is always without money, yet he always receives some. 12. How much do you think he has received lately? 13. He

received five hundred francs last week, but he will receive as many to-morrow. 14. We sold our garden, and shall also sell our house. 15. I cannot believe that he has not received our invitation. 16. Let us go, if not we shall lose our time uselessly. 17. If we are not careful, I fear that we shall lose what we have already gained. 18. The leaves begin to fall. 19. Those brave men all fought to the death.

KEY TO EXERCISE XXVIII.

1. We shall start. 2. If we had started. 3. Do not open. 4. Listen. 5. If they had followed. 6. They would suffer. 7. That poor woman suffered so much when her son left! 8. If the shopmen served us badly, we should have a right to take our custom elsewhere. 9. Open the window, it is too hot. 10. I would leave to-morrow if I had finished my business. 11. These children sleep too much. 12. As soon as they saw the danger, they all ran away and left him alone. 13. How many times have we heard them say that they were tired of studying! 14. Come with me. 15. Shun bad company, and follow the example of good men.

Continued

FRENCH Continued from page 3788 By Louis A. Barbé, B.A.

VERBS—continued
Third Conjugation

Recevoir, to receive. Principal Parts: *recevoir, recevant, reçu, je reçois, je reçus.*

INDICATIVE

SIMPLE TENSES	COMPOUND TENSES
Present	*Past Indefinite*
I receive, am receiving, etc.	I have received, etc.
je reçois	*j'ai reçu*
tu reçois	*tu as reçu*
il, elle reçoit	*il, elle a reçu*
nous recevons	*nous avons reçu*
vous recevez	*vous avez reçu*
ils, elles reçoivent	*ils, elles ont reçu*
Imperfect	*Pluperfect*
I was receiving, used to receive, etc.	I had received, etc.
je recevais	*j'avais reçu*
tu recevais	*tu avais reçu*
il, elle recevait	*il, elle avait reçu*
nous recevions	*nous avions reçu*
vous receviez	*vous aviez reçu*
ils, elles recevaient	*ils, elles avaient reçu*
Past Definite	*Past Anterior*
I received, etc.	I had received, etc.
je reçus	*j'eus reçu*
tu reçus	*tu eus reçu*
il, elle reçut	*il, elle eut reçu*
nous reçûmes	*nous eûmes reçu*
vous reçûtes	*vous eûtes reçu*
ils, elles reçurent	*ils, elles eurent reçu*
Future	*Future Anterior*
I shall receive, etc.	I shall have received, etc.
je recevrai	*j'aurai reçu*
tu recevras	*tu auras reçu*
il, elle recevra	*il, elle aura reçu*
nous recevrons	*nous aurons reçu*
vous recevrez	*vous aurez reçu*
ils, elles recevront	*ils, elles auront reçu*

CONDITIONAL

Present	*Past*
I would receive, etc.	I would have received
je recevrais	*j'aurais reçu*
tu recevrais	*tu aurais reçu*
il, elle recevrait	*il, elle aurait reçu*
nous recevrions	*nous aurions reçu*
vous recevriez	*vous auriez reçu*
ils, elles recevraient	*ils, elles auraient reçu*

IMPERATIVE

Present

reçois, receive (thou)
qu'il reçoive, let him receive
qu'elle reçoive, let her receive
recevons, let us receive
recevez, receive (ye)
qu'ils reçoivent, let them (m.) receive
qu'elles reçoivent, let them (f.) receive

SUBJUNCTIVE

Present	*Past*
That I may receive, etc.	That I may have received, etc.
que je reçoive	*que j'aie reçu*
que tu reçoives	*que tu aies reçu*
qu'il, qu'elle reçoive	*qu'il, qu'elle ait reçu*
que nous recevions	*que nous ayons reçu*
que vous receviez	*que vous ayez reçu*
qu'ils, qu'elles reçoivent	*qu'ils, qu'elles aient reçu*
Imperfect	*Pluperfect*
That I might receive, etc.	That I might have received, etc.
que je reçusse	*que j'eusse reçu*
que tu reçusses	*que tu eusses reçu*
qu'il, qu'elle reçût	*qu'il, qu'elle eût reçu*
que nous reçussions	*que nous eussions reçu*
que vous reçussiez	*que vous eussiez reçu*
qu'ils, qu'elles reçussent	*qu'ils, qu'elles eussent reçu*

INFINITIVE

Present	*Past*
recevoir, to receive	*avoir reçu*, to have received

PARTICIPLE

Present	*Past*
recevant, receiving	*reçu, e*, received
	ayant reçu, having received

The so-called regular third conjugation consists of only seven verbs. With the exception of *devoir*, to owe, and its derivative *redevoir*, still to owe, all the third conjugation verbs belong to the same group. They are: *apercevoir*, to

perceive; *concevoir*, to conceive; *décevoir*, to deceive; and *percevoir*, to perceive (receive impressions), and also to levy taxes.

It is to be noted that in these verbs the *c* takes a cedilla (ç) when it occurs before *o* or *u*. This is for the purpose of retaining the soft sound of *c* throughout the whole verb.

In *devoir*, the letter *d* takes the place of the *rec* of *recevoir*. Consequently, its principal parts are: *devoir, devant, dû, je dois, je dus.* The masculine form of the past participle takes a circumflex accent; the feminine form does not: *dû, due;* neither does the plural, *dus.*

Idiomatic Meanings of Devoir. 1. When *devoir* is used in the present, or the imperfect of the indicative, and followed by another verb in the infinitive, it is equivalent to the English "I am to," "I was to," "I have to." Examples: *Je dois prochainement recevoir de l'argent,* I am to receive some money shortly; *il doit y avoir demain une assemblée des actionnaires,* There is to be a meeting of the shareholders to-morrow; *Je dois aller demain à la campagne,* I have to go to the country to-morrow.

2. In the present indicative it sometimes expresses what is held to be a certainty, and is then to be translated by "must": *S'il a fait vingt milles, il doit être bien fatigué,* If he has walked (lit., done) twenty miles, he must be very tired.

3. In the same tense it may also express moral obligation. Example: *Un bon fils doit respecter son père,* A good son should respect his father.

4. In the present conditional (*je devrais,* etc.), *devoir* is to be translated by "ought"; and in the past conditional (*j'aurais dû,* etc.), by "ought to have." Example: *Vous devriez lui payer d'abord ce que vous lui devez,* You ought first of all to pay him what you owe him; *Vous n'auriez pas dû lui dire cela,* You ought not to have told him that.

5. In the past indefinite, and occasionally in the past definite and pluperfect (*J'ai dû, je dus, j'avais dû*), *devoir* implies obligation; *Jai dû lui donner quelque chose pour m'en débarrasser,* I had to give him something to get rid of him.

6. It is to be carefully noted that, in all these constructions, the verb following *devoir* is in the present infinitive.

EXERCISE XXVII.

1. We receive two papers every day.
2. She receives her friends on Thursdays (*le jeudi*).
3. We perceived a little white house at the foot of the hill.
4. Have you not yet received any reply (*réponse,* f.) to your letter?
5. It is easy to express (*énoncer*) clearly (*clairement*) what one conceives properly (*bien*).
6. When you receive this letter I shall no longer be in England.
7. About ten o'clock in the morning we perceived the hostile (*ennemi*) army in the distance (*lointain,* m.).
8. He owes his tailor fifty francs.
9. If you owe him so much, do you owe me nothing?
10. You ought to plant some trees along (*le long de*) that avenue (*allée,* f.).
11. When is there to be a meeting of the shareholders?
12. If good faith (*foi,* f.) were exiled from the rest of the earth, it ought to be found again (*se retrouver*) in the heart of kings.
13. You ought first of all to pay me what you owe me.
14. She must have been greatly astonished at (*de*) seeing you.
15. You ought to have returned (*rendre*) him the money which he has lent you.
16. If you have eaten nothing since this morning, you must be very hungry.
17. What time is it? It must be at least (*au moins*) half-past four.
18. I have received an invitation, but I have had to refuse it.

Fourth Conjugation

Vendre, to sell. Principal Parts: *vendre, vendant, vendu, je vends, je vendis.*

INDICATIVE

SIMPLE TENSES	COMPOUND TENSES
Present	*Past Indefinite*
I sell, am selling, etc	I have sold, etc.
je vends	*j'ai vendu*
tu vends	*tu as vendu*
il, elle vend	*il, elle a vendu*
nous vendons	*nous avons vendu*
vous vendez	*vous avez vendu*
ils, elles vendent	*ils, elles ont vendu*
Imperfect	*Pluperfect*
I was selling, used to sell, etc.	I had sold, etc.
je vendais	*j'avais vendu*
tu vendais	*tu avais vendu*
il, elle vendait	*il, elle avait vendu*
nous vendions	*nous avions vendu*
vous vendiez	*vous aviez vendu*
ils, elles vendaient	*ils, elles avaient vendu*
Past Definite	*Past Anterior*
I sold, etc.	I had sold, etc.
je vendis	*j'eus vendu*
tu vendis	*tu eus vendu*
il, elle vendit	*il, elle eut vendu*
nous vendîmes	*nous eûmes vendu*
vous vendîtes	*vous eûtes vendu*
ils, elles vendirent	*ils, elles eurent vendu*
Future	*Future Anterior*
I shall sell, etc.	I shall have sold, etc.
je vendrai	*j'aurai vendu*
tu vendras	*tu auras vendu*
il, elle vendra	*il, elle aura vendu*
nous vendrons	*nous aurons vendu*
vous vendrez	*vous aurez vendu*
ils, elles vendront	*ils, elles auront vendu*

CONDITIONAL

Present	*Past*
I would sell, etc.	I would have sold, etc.
je vendrais	*j'aurais vendu*
tu vendrais	*tu aurais vendu*
il, elle vendrait	*il, elle aurait vendu*

nous vendrions	*nous aurions vendu*
vous vendriez	*vous auriez vendu*
ils, elles vendraient	*ils, elles auraient vendu*

IMPERATIVE

Present

vends, sell (thou).
qu'il vende, let him sell
qu'elle vende, let her sell
vendons, let us sell
vendez, sell (ye)
qu'ils, qu'elles vendent, let them sell

SUBJUNCTIVE

Present	*Past*
That I may sell, etc.	That I may have sold, etc.
que je vende	*que j'aie vendu*
que tu vendes	*que tu aies vendu*
qu'il, qu'elle vende	*qu'il, qu'elle ait vendu*
que nous vendions	*que nous ayons vendu*
que vous vendiez	*que vous ayez vendu*
qu'ils, qu'elles vendent	*qu'ils, qu'elles aient vendu*

Imperfect	*Pluperfect*
That I might sell.	That I might have sold.
que je vendisse	*que j'eusse vendu*
que tu vendisses	*que tu eusses vendu*
qu'il, qu'elle vendît	*qu'il, qu'elle eût vendu*
que nous vendissions	*que nous eussions vendu*
que vous vendissiez	*que vous eussiez vendu*
qu'ils, qu'elles vendissent	*qu'ils, qu'elles eussent vendu*

INFINITIVE

Present	*Past*
vendre, to sell	*avoir vendu*, to have sold

PARTICIPLE

Present	*Past*
vendant, selling	*vendu, e*, sold
	ayant vendu, having sold

The stem of all regular verbs of the fourth conjugation, except *rompre*, to break, and its derivatives ends in *d*. In consequence of this these verbs do not take the *t*, which is the final letter of the third person singular of the present of the indicative: *il rend*. The *t* reappears in *rompre*: *il rompt*.

The fourth conjugation verbs used in the following exercise are:

attendre, to wait for	*mordre*, to bite
descendre, to come down, fall	*perdre*, to lose
entendre, to hear, understand	*rendre*, to return, render, yield
étendre, to stretch	*répondre*, to answer
fondre, to melt	*rompre*, to break, burst
	tondre, to shear

vendre, to sell

EXERCISE XXVIII.

1. Do you hear what I tell you?
2. Do not be afraid of the dog, it will not bite you.
3. You are always losing something.
4. Why have you not answered (to) his letter?
5. We heard some noise (*bruit*, m.), upstairs (*en haut*).
6. Let them wait for us now, we have waited long enough for them.
7. Wait for them; they are not ready (*prêt*) yet.
8. Do not lose so much time in (*à*) chattering (*bavarder*).
9. The enemy (pl.), coming down from their mountains, pillaged (*piller*) the whole district (*contrée*).
10. Those houses will be sold by auction (*aux enchères*) at eleven o'clock precisely.
11. I closed my eyes and I heard a frightful (*épouvantable*) din (*fracas*, m.).
12. You will lose nothing by (*pour*) waiting.
13. The discovery of America has greatly extended European commerce.
14. The Lord stretched out His hand over the sea, He shook (*ébranler*) the kingdoms.
15. The thermometer (*thermomètre*, m.) has fallen (*de*) four degrees since yesterday.
16. The young man thanked us without embarrassment for the service which we were rendering him.
17. Render unto Cæsar (*César*) that which belongs to Cæsar, and render unto God that which belongs to God.
18. The blows (*coup*, m.) which we feel (*sentons*) most are those which we can (*pouvons*) not return.
19. Some grains (*grain*, m.) yield a hundredfold (hundred for one), others sixty, and others thirty.
20. Samson broke his ropes (*corde*, f.) as one would break a thread (*fil*, m.).
21. To (the) shorn sheep God tempers (*mesurer*) the wind, says the proverb (*proverbe*, m.).
22. That dog is dangerous; it bites.
23. There are some persons whose praises (*louange*, f.) bite, and whose caresses (*caresse*, f.) scratch (*égratigner*).
24. Gold melts at a less degree (*degré*, m.) of heat (*chaleur*, f.) than iron.

KEY TO EXERCISE XXVI.

1. Quand j'étais enfant, j'étais très honteux, je rougissais jusqu'aux yeux quand on me parlait.
2. La terre n'est jamais ingrate; elle nourrit de ses fruits tous ceux qui la cultivent.
3. Ce n'est pas l'âge, c'est le chagrin qui a blanchi ses cheveux.
4. Si vous ne choisissez pas un bon endroit pour établir les fondations de la maison, vous serez obligé de la démolir.
5. La honte de cette action réfléchit sur tous ceux qui y ont participé.
6. Parmi les arbres, les amandiers fleurissent les premiers, et les néfliers les derniers.
7. Après tant de calamités il est étonnant que ce pays soit aujourd'hui si florissant.
8. Les armes qui ont été bénites par l'Église ne sont pas toujours bénies du ciel sur le champ de bataille.
9. Il y a des hommes dont il est glorieux d'être haï.
10. On ne hait pas toujours ceux que l'on rend malheureux.
11. Les bons livres guérissent les maladies de l'esprit.
12. Un peuple libre obéit, mais il ne sert pas.

Continued

GERMAN

Continued from page 3791

By P. G. Konody and Dr. Osten

LXXXV. Government of Adjectives. The following adjectives govern the genitive (answering the question wessen? whose?):

ansichtig, gewahr,* aware
bar, ledig, frei, los,* free
bedürftig, in want of
unbedürftig, not in want of
bewußt, conscious of
unbewußt, unconscious of
eingedenk, mindful
uneingedenk, unmindful
fähig, able
unfähig, unable
froh, glad
gewärtig, expecting
gewiß, sicher, certain, sure
gewohnt,* used to, accustomed
ungewohnt,* unaccustomed
gierig, begierig, eager, greedy
habhaft (werden),* to get possession of
kundig, expert
unkundig, unexpert
leer, empty
voll, full
mächtig, mighty
müde,* tired
satt,* überdrüssig,* satiated, weary, tired
schuldig, guilty
verdächtig, suspicious
teilhaftig, participating, sharing
verlustig, forfeited, deprived of
wert,* deserving, worthy
unwert, undeserving
würdig, worthy
unwürdig, unworthy.

EXAMPLES: Ich bin meines Versprechens eingedenk, I am mindful of my promise. Sie wurde meiner (genitive) ansichtig, She became aware of me. Die Polizei' wurde des Verbrechers hab'haft, The police got hold of the criminal. Ich bin dieser Sprache mächtig, I am master of this language. Er war seiner nicht mächtig, He had no command over himself. Dies ist nicht der Mühe (genitive) wert, This is not worth while. Der Arzt wurde seines Titels verlustig, The physician lost his degree, etc.

The adjectives in above list marked with * are, in ordinary speech, also used with the accusative, where the genitive would sound affected, especially with neuters of pronouns, like es, it; das, that (instead of the genitive dessen); dieses or dies, this; jenes, that; and with the indefinite pronouns and numerals etwas, nichts, manches, alles

EXAMPLES: Ich hatte es (accusative) satt, I had enough of it. Ich wurde den unwillkommenen Genossen (accusative) los, I got rid of the unwelcome companion. Er ist die Arbeit (accusative) nicht gewohnt, He is not accustomed to the work. But in some cases the adjectives are used with prepositions: thus it is preferable to say ich bin mit (preposition) allem (dative) zufrieden (I am content with everything), than Ich bin alles (accusative) zufrieden.

1. The following adjectives govern the dative (answering the question wem? to whom?):

ähnlich,* similar, like
an'geboren, inborn, innate
an'gehörig, related to
an'gelegen, important, pressing
an'gemessen,* commensurate, suitable
an'genehm,* agreeable
an'stößig, offensive
är'gerlich, annoying, vexatious, fretful
auf'fällig,* striking, conspicuous
bedenk'lich,* doubtful, suspicious
begreif'lich,* comprehensible
behag'lich,* comfortable
behilf'lich, serviceable, useful
bekannt,* known, acquainted
bequem',* convenient, comfortable
beschwer'lich, cumbersome, troublesome
bewußt',* conscious
böse, wicked, bad, ill
dank'bar,* grateful
deut'lich,* clear, distinct
dien'lich, serviceable
eigen, own, proper
eigentümlich, peculiar
ekelhaft (eklig), nasty
empfind'lich,* sensitive
entbehr'lich,* dispensable
erfreu'lich,* delightful, pleasing
erge'ben, devoted
erin'nerlich, present in one's mind
erwünscht, wished for, welcome
feind (feindselig), hostile
fern, far, distant
förderlich, useful, beneficial
fremd, strange
furchtbar, fürchterlich, terrible
gedeihlich, prosperous, thriving
gefährlich,* dangerous
gehor'sam,* obedient
gewachsen, to be a match for
gleich, equal
gleichgültig, callous, indifferent
gemäß, according to
gemein, common, mean
gemeinsam, gemeinschaftlich, common, mutual
geneigt, disposed, inclined
getreu,* faithful to
gnädig,* gracious
gram, averse, hostile
günstig,* favourable
gut, good
heilsam, salutary, beneficial
hinderlich, impeding, troublesome
hold, amiable, sweet
klar,* clear, bright
kund, known, notorious
lästig, burdensome
leicht, easy, light
leid, sorry
lieb, dear, beloved
möglich,* possible
nachteilig, disadvantageous
nahe, near
natürlich,* natural
nötig,* notwendig, necessary
nützlich, useful
rätselhaft, enigmatic
schäd'lich, pernicious
schmeichelhaft,* flattering
schmerzlich, painful
schuldig, guilty
schwer, difficult, heavy
sicher, certain
tauglich, fit
teuer, dear
treu,* true, faithful
treulos, untrue, faithless
überle'gen, superior
unausstehlich, insupportable
unerwartet, unexpected
untertan, subject (to)
unvergeßlich, unforgetable
unwiderstehlich, irresistible
verant'wortlich, responsible
verderb'lich, pernicious
verhaßt, hated
verwandt, related
vor'teilhaft,* advantageous
wert, worth
wichtig, important
widrig, adverse, contrary
widerwärtig, repugnant
willfährig, compliant
willkommen, welcome
wunderbar, marvellous
zu'gänglich, accessible
zu'getan, devoted
zu'träglich, becoming

The adjectives marked in above list with * take the prefix un- to convey the opposite (negative meaning): ähnlich, like; un-ähnlich, unlike.

EXAMPLES: Er ist seinem Bruder (dative) ähnlich, He resembles his brother. Die Botschaft war dem König (dative) angenehm, The message was pleasing to the king. Ich bin Ihnen (dative) dankbar, I am grateful to you. Das Kind blieb seinem Versprechen (dative) treu, The child remained

true to its promise. Der Hagel ist dem Getreide schädlich, The hail is harmful to the corn.

LXXXVI. Co-ordinate Clauses. Sentences or clauses that have the same grammatical value can be connected in different ways:

(*a*) The clauses agree in sense: Die Nacht war kalt, **und** die Straßen waren menschenleer, The night was cold, and the streets were deserted.

(*b*) One clause modifies or limits the other: Der Regen war dem Wachstum förderlich, **aber** der Hagel zerstörte Alles, The rain was beneficial to (the) growth, but the hail destroyed everything. Er wollte gehen, **doch** er konnte nicht, He wanted to go, but he could not.

(*c*) One clause is explained by the other: Das Wasser ist gesund, **denn** es enthält Eisen, The water is wholesome, as it contains iron.

(*d*) One clause is the consequence of the other: Er ist sehr gutherzig, **deshalb** wird er von Bettlern umlagert, He is very kind-hearted, therefore he is besieged by beggars.

The connection of co-ordinate clauses is effected by the use of (*a*) copulative, (*b*) adversative, (*c*) causal, and (*d*) consecutive conjunctions.

LXXXVII. Subordinate Clauses. The auxiliary finite verb, which normally stands at the end of the subordinate clause in the compound tenses, may be transposed if the clause contains dependent infinitives: Ich wünschte, daß du ihn **hättest** (finite verb) kennen lernen, I wished that you had got to know him, is better than the clumsy form: Ich wünschte, daß du ihn kennen lernen hättest.

1. Subordinate clauses are never employed if the idea can be clearly expressed without them. Thus, Ich bat ihn, daß er mir sage, wohin sie gegangen sei (literally: I begged him to tell me where she had gone) can be expressed far better and more briefly in the following way: Ich bat ihn mir zu sagen, etc. Subordinate clauses are connected with the principal sentence by subordinative conjunctions, and relative pronouns.

2. The subordinate clause can be placed (*a*) at the beginning, (*b*) in the middle, (*c*) at the end of the compound sentence. (*a*) **Daß die Nacht hereinbrach** (subordinate clause), machte uns besorgt, That the night set in made us uneasy; (*b*) Der Umstand, **daß die Nacht hereinbrach**, machte uns besorgt, The fact that night set in made us uneasy; (*c*) Es machte uns besorgt, **daß die Nacht hereinbrach**, It made us uneasy that, etc.

3. Some ideas cannot be expressed by simple nouns, but require entire subordinate clauses to elucidate their meaning. At times, too, a noun is replaced by a subordinate clause for the sake of stress, euphony, rhythm, or clearness. Thus a subordinate clause always stands for some part of the principal sentence—the subject, the object, an attribute, or an adverbial adjunct, and according to its function, the dependent clause is either a *subject clause*, an *object clause*, an *attributive* (*adjective*) *clause*, or an *adverbial clause*.

EXAMINATION PAPER XXI.

Correct the following sentences by changing the nominative, which is employed throughout, into the correct cases required by the adjectives.

Ich war **meine Pflicht** eingedenk. Der Sohn
I was mindful of my duty. The son
ist **sein Vater** ähnlich. Die Lüge war
resembles his father. The lie was
die Athener angeboren. Die Sache schien
innate in the Athenians. The affair seemed
der Beamte bedenklich. Er hielt ihn
suspicious to the official. He thought him
ein solches schreckliche Verbrechen fähig.
capable of such a horrible crime.
Der Gefangene war **das Urteil** gewärtig.
The prisoner was expecting the verdict.
Die Eltern sind **die Sprache** nicht mächtig.
The parents have not command of the language.
Die Soldaten waren **der Dienst** überdrüssig.
The soldiers were weary of the service.
Die Soldaten war der Dienst überdrüssig.
The service was wearisome to the soldiers.
Das Kind ist **seine Eltern** Gehorsam schuldig.
The child owes obedience to its parents.
Diese Handlung ist **du** unwürdig. Man
This action is unworthy of you. They (people)
überhob mich **die Mühe**. Die Verfolger
spared me the trouble. The pursuers
wurden **der Dieb** habhaft. Dieser Zwischenfall
got hold of the thief. This incident proved
erwies sich **ich** günstig. Das ist **sie** ganz gleichgültig.
favourable to me. This is quite indifferent to her.
Das Volk ist **der König** untertan. Trotzdem
The people is subject to the king. Though
der Fall **der Richter** unklar war, fand er ihn
the case was not clear to the judge, he found him
das Verbrechen schuldig. Der Feldherr
guilty of the crime. The commander-in-chief
war **diese große Überzahl** nicht gewachsen,
was not equal to such overpowering numbers,
und ergab sich, als er **die heranrückende frische Truppen** ansichtig wurde.
and surrendered when he got sight of the approaching fresh troops.

CONVERSATIONAL EXERCISES

V. Laundry and Washing

I have some dirty linen, can it be washed?	Ich habe einige schmutzige Wäsche, kann sie gewaschen werden?
Oh, yes; give it to me, please.	O ja, bitte geben Sie sie mir.
When can I get it back?	Wann kann ich sie wieder haben?
In four or five days.	In vier bis fünf Tagen.

That is too late; I must have it to-morrow, as I start in the evening.	Das ist zu spät; ich brauche sie schon morgen, da ich Abends abreise.
Very well, I shall try to make it possible.	Sehr wohl, ich werde trachten es möglich zu machen.
I have 4 shirts, 6 collars, 4 pairs of cuffs, 10 handkerchiefs, 3 pairs of socks, and 3 pairs of pants. The shirts must not be starched.	Ich habe 4 Hemden, 6 Kragen, 4 Paar Manschetten, 10 Taschentücher, 3 Paar Socken und 3 Paar Unterbeinkleider. Die Hemden dürfen nicht gestärkt werden.
Everything shall be done as you wish.	Alles soll nach Wunsch besorgt werden.
Can I rely on everything being delivered in time?	Kann ich mich darauf verlassen, daß Alles rechtzeitig geliefert wird?
Certainly, sir.	Gewiß, mein Herr.

VI. At the Telegraph Office

I want to send a wire to England.	Ich wünsche ein Telegramm nach England aufzugeben.
How much a word? Twenty pfennigs.	Was kostet das Wort? 20 Pfennige.
Can I have a form?	Kann ich ein Formular haben?
How must I mark it for reply paid?	Welche Bezeichnung ist für bezahlte Rückantwort erforderlich?
R. p., sir.	R. p., mein Herr (Réponse payée).
How many letters may a single word contain?	Wie viele Buchstaben darf ein einfaches Wort enthalten?
Sixteen, sir; more letters in a single word are charged as two words.	Sechszehn, mein Herr; mehr Buchstaben in einem Wort werden als zwei Worte gerechnet.
Is the handwriting legible?	Ist die Schrift gut leserlich?
Oh, yes; only this letter is not quite clear.	O ja, nur dieser Buchstabe ist nicht ganz deutlich.
When does the telegram reach London?	Wann kann das Telegramm in London sein?
In about three hours.	In ungefähr drei Stunden.
Can I have telegrams forwarded?	Kann ich mir Telegramme nachsenden lassen?
Certainly, if you let me know your new address and fill in this form.	Gewiß, wenn Sie mir Ihre neue Adresse mitteilen und diese Form ausfüllen.
How many words does the telegram contain?	Wie viel Worte enthält das Telegramm?
Is the signature to be wired as well?	Soll die Unterschrift auch telegraphiert werden?
No, only the surname.	Nein, nur der Familienname.

Continued

SPANISH

By Amalia de Alberti & H. S. Duncan

REGULAR VERBS

Spanish verbs have three conjugations. All verbs, regular or irregular, ending in *ar* belong to the first conjugation. Example: *Amar*, to love.

All those ending in *er* belong to the second conjugation. Example: *Comer*, to eat.

All those ending in *ir* belong to the third conjugation. Example: *Vivir*, to live.

Regular verbs are those in which the terminations conform to the model verb of their conjugation; these terminations are applied directly to the unchanged stem found by suppressing the infinitive ending. Examples:

am-*ar*; am-*amos*—to love; we love
com-*er*; com-*emos*—to eat; we eat
viv-*ir*; viv-*imos*—to live; we live

Those verbs which by changes in stem and termination differ from the model verb of their conjugation are called irregular.

This, however, does not apply in the case of orthographic changes in certain regular verbs, made for the sake of euphony only. These will be pointed out later.

First Conjugation

MODEL VERB: **Amar,** to love

INFINITIVE	GERUND
amar, to love	*amando*, loving

PAST PARTICIPLE
amado, loved

INDICATIVE MOOD

Simple Tenses

Present	*Imperfect*
amo, I love	*amába*, I was loving
amas, thou lovest	*amábas*, thou wast loving
ama, he loves	*amába*, he was loving
amamos, we love	*amábamos*, we were loving
amais, you love	*amábais*, you were loving
aman, they love	*amában*, they were loving

Past Definite	*Future*
amé, I loved	*amaré*, I shall love
amaste, thou lovedst	*amarás*, thou wilt love
amó, he loved	*amará*, he will love
amamos, we loved	*amarémos*, we shall love
amásteis, you loved	*amaréis*, you will love
amáron, they loved	*amarán*, they will love

CONDITIONAL MOOD

amaría, I should love
amarías, thou wouldst love
amaría, he would love
amaríamos, we should love
amaríais, you would love
amarían, they would love

IMPERATIVE MOOD

ama, love (thou)	*amémos*, let us love
ame, let him love	*amád*, love ye
	amen, let them love

SUBJUNCTIVE MOOD

Present	*Imperfect*
ame, I may love	*amára*, or *amáse*, I might love
ames, thou mayst love	*amáras*, or *amáses*, thou mightst love
ame, he may love	*amára*, or *amáse*, he might love
amémos, we may love	*amáramos*, or *amásemos*, we might love
améis, you may love	*amárais*, or *amáseis*, you might love
amen, they may love	*amáran*, or *amásen*, they might love

Future

cuando yo amáre, when I shall love
cuando tu amáres, when thou wilt love
cuando él amáre, when he will love
cuando nosotros amáremos, when we shall love
cuando vosotros amareis, when you will love
cuando ellos amáren, when they will love

COMPOUND TENSES

Infinitive Past

haber amado, to have loved
habiendo amado, having loved

INDICATIVE MOOD

Past Indefinite

hé amado, I have loved
has amado, thou hast loved
há amado, he has loved
hemos amado, we have loved
habeis amado, you have loved
han amado, they have loved

Pluperfect

había amado, I had loved
habías amado, thou hadst loved
había amado, he had loved
habíamos amado, we had loved
habíais amado, you had loved
habían amado, they had loved

Past Anterior

hube amado, (when) I had loved
hubiste amado, thou hadst loved
hubo amado, he had loved
hubimos amado, we had loved
hubisteis amado, you had loved
hubieron amado, they had loved

Future Perfect

habré amado, I shall have loved
habrás amado, thou wilt have loved
habrá amado, he will have loved
habrémos amado, we shall have loved
habréis amado, you will have loved
habrán amado, they will have loved

CONDITIONAL MOOD

habría amado, I should have loved
habrías amado, thou wouldst have loved
habría amado, he would have loved
habríamos amado, we should have loved
habrías amado, you would have loved
habrían amado, they would have loved

SUBJUNCTIVE MOOD

Past Indefinite

haya amado, I may have loved
hayas amado, thou mayst have loved
haya amado, he may have loved
hayamos amado, we may have loved
hayais amado, you may have loved
hayan amado, they may have loved

Pluperfect

hubiera, or *hubiese amado*, I might have loved
hubieras, or *hubieses amado*, thou mightst have loved
hubiera, or *hubiese amado*, he might have loved
hubiéramos, or *hubiesemos amado*, we might have loved
hubierais, or *hubieseis amado*, you might have loved
hubieran, or *hubiesen amado*, they might have loved

Future Perfect.

hubiere amado, (when) I shall have loved
hubieres amado, thou wilt have loved
hubiere amado, he will have loved
hubiéremos amado, we shall have loved
hubiéreis amado, you will have loved
hubieren amado, they will have loved

Second Conjugation

MODEL VERB: **Comer,** to eat

INFINITIVE	GERUND
comer, to eat	*comiendo*, eating

PAST PARTICIPLE

comido, eaten

INDICATIVE MOOD

Present	*Imperfect*
cómo, I eat	*comía*, I was eating
comes, thou eatest	*comías*, thou wast eating
come, he eats	*comía*, he was eating
comémos, we eat	*comíamos*, we were eating
coméis, you eat	*comíais*, you were eating
comen, they eat	*comían*, they were eating

Past Definite	*Future*
comí, I ate	*comeré*, I shall eat
comiste, thou atest	*comerás*, thou wilt eat
comió, he ate	*comerá*, he will eat
comimos, we ate	*comerémos*, we shall eat
comisteis, you ate	*comeréis*, you will eat
comiéron, they ate	*comerán*, they will eat

CONDITIONAL MOOD

comería, I should eat
comerías, thou wouldst eat
comería, he would eat
comeríamos, we should eat
comeríais, you would eat
comerían, they would eat

IMPERATIVE MOOD

come, eat (thou)	*comámos*, let us eat
coma, let him eat	*comed*, eat (ye)

coman, let them eat

SUBJUNCTIVE MOOD

Present

coma, I may eat	*comámos*, we may eat
comas, thou mayst eat	*comais*, you may eat
coma, he may eat	*coman*, they may eat

Imperfect

comiera, or *comiese*, I might eat
comieras, or *comieses*, thou mightst eat
comiera, or *comiese*, he might eat
comiéramos, or *comiésemos*, we might eat
comiérais, or *comiéseis*, you might eat
comieran, or *comiesen*, they might eat

Future

comiere, when I shall eat	*comiéremos,* when we shall eat
comieres, when thou wilt eat	*comiéreis,* when you will eat
comiere, when he will eat	*comieren,* when they will eat

REMARKS. In the first conjugation the accent distinguishes identical forms. Example: *Amo,* I love; *amó,* he loved. In the first case the stress is laid on *a*, in the second on *o*.

In the second conjugation, *cómo,* I eat, takes an accent to distinguish it from *como,* as.

The compound tenses are formed as in the case of *amar* with the verb *haber* and the past participle *comido.* Example: *He comido,* I have eaten, etc.

Vocabulary	**Vocabulario**
To buy	Comprar
To calculate	Calcular
To compare	Comparar
To devour	Devorar
To wish	Desear
To demonstrate	Demostrar
To remain	Quedarse
To eclipse	Eclipsar
To edify	Ynstruir
To embroil	Embrollar
To muffle	Embozar
To empower	Facultar
To give sentence (judicial)	Fallar
To fatigue	Fatigar
To congratulate	Felicitar
To run	Correr
To enter	Entrar
To deliver	Entregar
To give sparingly	Escatimar
The famine	El hambre
The skirt	La falda
A flounce	Un volante
The lantern, lighthouse	La linterna, e faro
The luggage	El equipaje
The watch-tower	La atalaya
The short-cut	El atajo
The main road	El camino real
The village	La aldea
Hasten	Prisa (darse)
The jail	La cárcel
The prisoner	El prisionero
A problem	Un problema
Prismatic	Prismático
Favourite	Favorito
A prophet	Un profeta
A ravine	Una barranca
Brittle	Quebrajoso
The complaint	La queja
Perhaps	Quizá
A parasol	Una sombrilla
The Bible	La Biblia
Biblical	Bíblico
A parable	Una parábola
The Gospel	El Evangelio
The evangelist	El evangelista
To evangelise	Evangelizar
To excavate	Excavar

EXERCISE XII. (1)

Translate the following into Spanish:

1. I buy meat, eggs, and milk at the farm; the farmer is very honest. 2. I, too, shall buy them there, and we shall also, my daughter and I, buy fowls (there). 3. Do you eat many birds? 4. Yes, we are very fond of them. 5. I eat a great deal of game; we have bought partridges and pheasants. 6. I wish to demonstrate this problem to you. 7. The judge has given sentence in the lawsuit. 8. Shakespeare's fame has reached to the end of the world. 9. That woman friend of yours is capable of embroiling the most united family. 10. Driving along the main road the carriage upset, and the coachman and the horses were hurt. 11. They took the prisoner in haste to the prison. 12. Perhaps the doctor may come to see me; my son complains of headache. 13. Open your parasol; the sun is hot. 14. When they excavated in the ravine, they found a beautiful statue. 15. The lantern (of the lighthouse) of the port of Cadiz is seen very far off. 16. They have stolen my money from my pocket. 17. When was this? 18. When I went to buy the Bible for the children. 19. I wish you a happy New Year.

NOTE. Students should now attempt to translate the exercise with the aid of a good dictionary, such as the new edition of Velasquez' Spanish Dictionary (published by Hachette, King William Street, Strand. 10s. 6d. net).

EXERCISE XII. (2)

Translate the following into English:

1. Los huérfanos amaban á su padre. 2. Los estudiantes áman á su perro. 3. Amaré á mis hijos. 4. No dejes de amar á tu enemigo, así lo manda el Evangelio. 5. Coman con nosotros. 6. Comerémos con Vds con mucho gusto. 7. Un ciego no necesita ver para comer. 8. Es mejor reir que llorar. 9. Ganó su pleito, y dió una gran comida. 10. Los sordos mudos pueden hablar con los dedos. 11. El actor declamó muy bien. 12. Los canarios cantan, y los perros ladran. 13. Cuando vamos al huerto comemos fruta.

PROSE EXTRACT X.

From "El Buey Suelto" (The Unyoked Ox).

By José de Pereda.

Grant me, reader, if you have no objection, that when a man has been accustomed from his earliest years to have the ordinary and most pressing needs of life supplied as if by magic, he is well on the way to be an egoist. This does not prevent the man who has won the goods he enjoys in a fierce struggle with Fate from being an egoist also.	Concédame el lector, si mal no le parece, que cuando un hombre ha visto desde que empezó á serlo, satisfechas como por ensalmo las mas comunes y perentorias necesidades de la vida, tiene mucho adelantado para ser egoista. Lo cual no se opone á que también lo sea el que ha ganado el bien que disfruta en guerra encarnizada con la suerte.

Is that to say that egoists abound, that the species varies with every specimen? Agreed; but it will be well to draw a distinction between the cases as regards the subject of these reflections.

¿ Querrá decir esto que los egoistas abundan, y que sus especies varían en cada ejemplar ? Enhorabuena, pero conviene distinguir el caso para el objeto de estos apuntes.

He who is selfish because he has been made so by the ill-usage of Fortune, he who devotes himself to his own enjoyment as a reward for bygone hardships, finds an excuse in this, and a perennial delight in comparing the smiling present with the anxious past. Thus, imagination does not beguile him, changes cannot bewilder him, neither is he "the slave of habit," according to the popular saying applied to those waverers who deplore imaginary evils from excess of good. His course lies clear before him and he follows it firmly, without any risk of stumbling into error from the very fact that he has no illusions to light the way.

El que es egoista porque así le hizo el desdén de la fortuna, el que se consagra al propio regalo como en recompensa de pasadas fatigas, tiene en éstas la disculpa, y perenne deleite en la comparación del presente ruiseño con el ayer angustioso. De este modo, ni la imaginación le seduce, ni las vacilaciones le marean, *ni el vicio le mata*, como el vulgo dice de los indecisos que lloran soñados males por exceso de bienes. Lleva su rumbo bien trazado, y camina con pié firme, sin el riesgo de tropezar en desengaños, por lo mismo que no se alumbra con ilusiones.

The case of Gideon is very different; he is a type which includes all kinds of egoists who ought not to be so, even from selfish motives.

Otra cosa muy distinta es Gedeón, tipo en que se resumen todas las especies de egoistas que no debieran serlo, hasta por razones de egoismo.

To these gentlemen I address my tale. I speak to you; to you, who, eager to avoid material annoyances, fly from the most legitimate joys of the spirit; to you, prodigal of your substance, when it is a case of pampering the body and niggards of it when your soul requires a halfpenny to purchase joy.

A estos señores enderezo mi cuento; con vosotros hablo; con vosotros, los que afanados en evitarle desazones de la materia, huís de los más legítimos goces del espíritu; con vosotros los que, pródigos de la hacienda cuando se trata de regalar al cuerpo, sois avaros de ella si el alma os pide un óbolo para adquirir un regocijo.

José de Pereda (1834), a master of the provincial novel, renowned for his power of description and realistic pictures of peasant life in the mountains. The novel of which our extract is the opening is a satirical history of the miseries and misadventures of an old bachelor, partly intended as a reply to Balzac's novel "Petites Misères de la Vie Conjugale."

José de Pereda (1834), pasado maestro en las novelas provincialas, afamado por su poder descriptivo y pinturas realisticas de la vida aldeana en la montaña. La novela de la cual nuestro extracto es el principio, es una história satírica de las miserias y desventuras de un soltero viejo, en parte escrita como contestacion á la novela de Balzac. "Petites Misères de la Vie Conjugale."

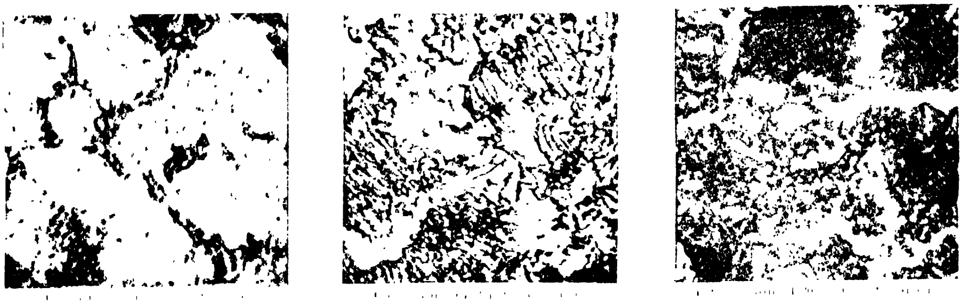
Key to Exercise XI. (1)

1. El amor al dinero trae la avaricia. 2. El ser pródigo no es siempre tener caridad. 3. La actividad vence la apatía y la pereza. 4. El ser ilusivo es tener poca conciencia. 5. La incredulidad es una triste cosa. 6. La curiosidad demuestra una imaginación poco ocupada. 7. La desesperación no es cristiana. 8. Muchos hablan, pocos son elocuentes. 9. El entusiasmo hace el hombre heróico. 10. La erudición no es siempre sabiduria. 11. Los celos hacen la desgracia de los celosos. 12. El celo es una virtud. 13. La gratitud demuestra nobles sentimientos. 14. En el peligro la presencia de espíritu vale mucho. 15. El remordimiento no remedia el mal hecho. 16. La necedad es siempre orgullosa. 17. La vanidad es tonta. 18. La ociosidad es madre de todos los vicios. 19. El aseo es una gran cualidad. 20. El desaseo es desagradable. 21. El pensamiento es dado al hombre para guiarlo.

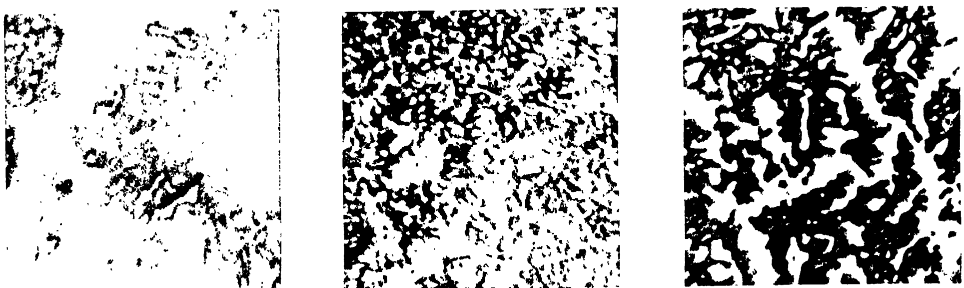
Key to Exercise XI. (2)

1. I am aged. I am an old woman. 2. We are hungry. Eat bread and meat. 3. They are not guilty; I am guilty of this crime. 4. I am ashamed to have spoken against my neighbour. I am ashamed! 5. They are right, I am reasonable. 6. I am thirsty. Drink water and wine. 7. Let us have patience. 8. Thou art a fool to talk thus. 9. She is a beautiful woman, and has money. 10. We are fortunate to have such a celebrated father. 11. They will be punished for their crimes. 12. He would be a man of talent if he were not so vain. 13. Thou wast amiable to sing. 14. He is a braggart and a liar. 15. Let us have courage. 16. Originality in a man of letters is a great quality. 17. Love of liberty is natural to man. 18. Insolence is unpardonable. 19. It is well to ascertain the truth. 20. Exaggeration sometimes amounts to falsehood. 21. It is well to count one's money before spending it.

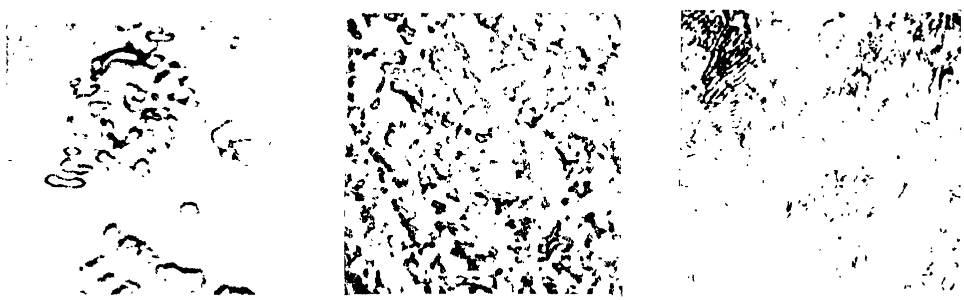
Continued



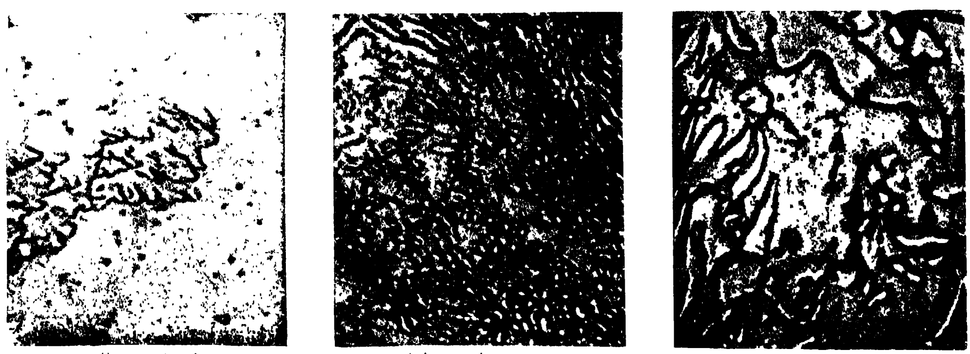
ROLLED STEEL BARS IN ORDINARY CONDITION



THE SAME BARS AFTER ANNEALING FOR [illegible] MINUTES AT [illegible]



THE SAME BARS AFTER SOAKING FOR [illegible] HOURS AT [illegible]



(e) Intermediate position

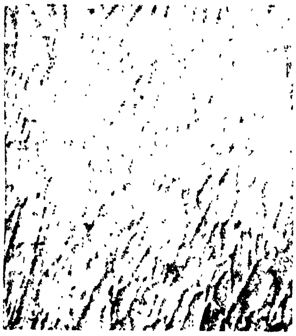
(f) Centre of casting

MALLEABLE IRON CASTING

MICROGRAPHIC SPECIMENS OF IRON AND STEEL [See page 398]

Magnification, 1,600 diameters

[illegible]



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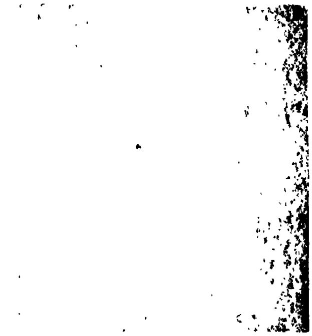

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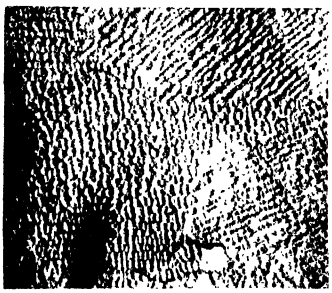

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MICROGRAPHIC SPECIMENS OF METALS (See page [illegible])

METALS UNDER THE MICROSCOPE

The New Science of Metallography. Preparing Specimens. Alloys and their Preparation. Characteristics and Composition of Alloys

Continued from page 3839

By A. H. HIORNS

Metallography. The branch of metallurgical science termed *metallography* is, in the broadest sense of the word, the description of the structure of metals and alloys. It is not necessarily limited to the employment of the microscope or even to the hand glass, for the fractured surface of a metal often reveals valuable information when viewed with the naked eye. We form an opinion of the nature of metals also from their colour, their manner of solidifying in a mould, and the texture of their surfaces. But only very limited information as to the structure of metals can be obtained by simply using the unaided eye to examine the rough or unpolished surface. The structure of what may be termed the *internal architecture* of metals can be accurately ascertained only by the use of the microscope, generally on the polished and etched surface.

Microscopic Investigation. One of the great results of the microscopic investigation of metals has been the confirmation of their crystalline character, even in metals in which such a structure could not have been anticipated or proved by other means. The appearance of the polished structure of a metal under the microscope seldom reveals definite and well-formed crystals—in fact, the conditions of solidification from the molten state and the mechanical treatment to which most metals are subjected militate against the formation and retention of the true external crystalline form. The result is a compact mass of irregular-shaped bodies termed *crystal grains*, giving the surface the appearance of a mosaic with irregularly shaped stones.

Character of Crystal Grains. In the act of solidifying, crystals begin to form and gradually grow in size according to the time allowed for their development. The junction lines are the surfaces of the crystals, and appear as thin dark lines in the micro-structure. If impurities be present, the crystals of the pure metals in the act of crystallising reject such impurities, which collect at the crystal boundaries. The particles of the pure metal coalesce together so as to form little islands surrounded by the impurity, which thus forms the investing membrane, separating the crystals from each other.

Obviously, the mechanical and physical properties of an alloy will depend largely on the nature of the investing membrane, since the crystals themselves may be quite malleable and ductile, while the mass of the metal, with the including impurities, may be quite brittle. The main factor in the development of crystalline structure is the temperature. It is a well-recognised fact that the more slowly a metal is cooled from the freezing point, the larger will be the dimensions of the crystals, the more perfectly will they be formed, and the more symmetrically will they arrange themselves with regard to each other. On the other hand, if a metal be submitted to pressure, not only will the individual crystals be distorted, but the orderly arrangement of the whole mass will be disturbed. Messrs. Ewing and Rosenhaim have shown that when a piece of metal is strained in tension its crystal grains become elongated in the direction of the tension; but when the metal has been annealed all signs of the elongation disappear from the crystalline pattern revealed by the microscope, and the metal has assumed its original condition. On investigating the metal under strain, when the metal is stretched beyond its elastic limit it has also been found that sharp and fine black lines appear on the surface of the crystals, parallel to each other in each crystal but in different directions in different crystals. These lines are not cracks, but *slips* along the cleavage or guiding planes, and are termed *slip-bands*. Such bands are also produced by compression or tension, and it is in virtue of this action that plasticity in metals is possible.

Preparing Metals for the Microscope. For exact examination of the structure of metals it is absolutely necessary to have the surface polished free from scratches, as well as perfectly flat, if high powers are to be used, since scratches and other imperfections tend to mask the real structure and convey an erroneous impression regarding the character of the components. Polishing is an art requiring skill and patience, and while no exact rules can be given to cover all cases, the following will serve as a general guide. The section of metal should be about ½ in. square, and ¼ in. thick. It may be mounted for final examination on a glass slide with Canada balsam, plasticine, wax, or other suitable adhesive materials, or soldered on to a flat piece of metal. The first process is to rub it smooth on a dead-smooth file, and afterwards to remove the scratches with emery and rouge. Different grades of emery can be purchased, marked O, OO, OOO, and OOOO, respectively. Each grade should be mounted on a smooth block, and the specimen rubbed on each in turn, care being taken to rub at right angles to the former rubbing, so as to obliterate the previous marks completely. The final polishing may be done on a skin of chamois leather coated with the very finest rouge.

Etching the Specimens. Various etching liquids are used, varying with different metals. Those employed for steel are dilute nitric acid, tincture of iodine, infusion of liquorice, ammonium nitrate and picric acid; for copper and brass, dilute nitric acid, hydrochloric acid and

ammonia; while for alloys with much zinc, potash is the best reagent. In fact, numerous etching liquids are available.

It is sometimes an advantage to polish in bas-relief. When a complex body is polished, its different constituents tend to wear away unequally, and it is possible, by placing it in convenient positions, to show the structure by the unequal relief. To do this, the section is polished on a bed elastic enough to bring out the finest details, such as parchment on soft wood, and moistened with wet rouge. Another method of polishing is known as *polish attack*. This consists of adding to the polishing pad some liquid which exerts a slight chemical action when assisted by the friction of the rubbing.

Heat Tinting. Etching polished metals with corrosive liquids is more or less liable to lead to the confusing of the constituents and crystalline structure. With feeble etching the component parts are, as a rule, revealed; with strong etching the granular, and often the crystalline structures, are developed. By heating polished sections at different temperatures the constituents become differently coloured by oxidation films, and may therefore be detected. This has the advantage over etching, that none of the metal is dissolved, and the surface remains flat.

The Microscope. A very simple form of microscope is all that is necessary for examining metals, but the lenses must be of good quality. The objectives must give a flat field, should be achromatic, and should possess clear definition. A bull's-eye condensor is required for condensing the light on to the object, or on to the vertical illuminator.

The most useful objectives are 1 in. and ¼ in., which give magnifications from 50 to 200 diameters. Two kinds of illuminators are in use, termed respectively *oblique* and *vertical* illuminators. In the former, the microscope is generally tilted at an angle, and the light thrown directly on the object, which reflects it to the eye. For vertical illumination a piece of glass is arranged at an angle of 45 degrees, so as to reflect a horizontal beam of light on the object, which then reflects the light vertically up the tube of the microscope to the eye. Instead of the plane glass reflector, a right-angled prism may be used. It is fixed in a brass mounting, and may be placed just above the objective, or just under the eye-piece.

Iron and Steel. *Wrought iron* is composed of three chief parts: the crystals of iron, termed *ferrite*, the carbide of iron, termed *cementite*, and the included slag which imparts to iron its fibrous structure. *Cast iron* is of two chief kinds—namely, grey cast iron, consisting chiefly of ferrite and graphite; and white cast iron, containing no free ferrite, but iron combined with carbon in a form which imparts to it a white crystalline structure and great hardness. *Steel* is composed of different components, according to the amount of carbon present. When the steel contains less than 0·9 per cent. of carbon, it consists of ferrite embedded in a matrix of what is termed *pearlite*, which is an intimate mixture of ferrite and cementite in alternate laminæ. When the steel contains just 0·9 per cent. of carbon, the whole mass is composed of pearlite, with no free crystals of ferrite. This is termed the *eutectic mixture*, and the iron is said to be saturated with carbon. When the steel contains over 0·9 per cent. of carbon, it consists of crystals or grains of pearlite, surrounded by a network of cementite, which hardens the steel according to the quantity present.

A section of pure iron, when polished and etched in dilute nitric acid, is seen to consist of irregular-shaped grains or crystals. Two disdinct types are generally observed: (1) smooth and bright areas consisting of pure iron (ferrite); and (2) greyish rough areas of a wavy or mottled appearance, being more readily attacked by nitric acid. When carbon is present the crystals of ferrite are surrounded by a matrix of pearlite, which encroaches more and more on the ferrite as the carbon is increased, as shown in the plates following pages 2936 [2 and 3]. The pearlite matrix is seen in the latter to have a characteristic banded structure. When the steel contains about 0·9 per cent. of carbon, the whole mass consists of pearlite. When the carbon is increased beyond 0·9 per cent., the ferrite crystals have entirely disappeared and have been replaced by pearlite; the excess of carbon over 0·9 per cent. then appears in combination with iron as free cementite, as seen in **4**. These three figures represent the steel in the normal state.

Effects of Annealing Steel. On annealing steel a change is produced in the physical properties, and this change is coincident with a change in structure. By *annealing* is meant heating to a certain elevated temperature and cooling slowly to the ordinary temperature. The effect on the micro-structure by annealing is seen in **5** and **6**. The changes which have been produced occurred mainly in the ferrite, but the pearlite has become more granular. The effect of annealing high carbon steel at 620° C., as seen in **7**, is chiefly to sharpen the outline of the cementite. The above remarks apply also to **8**, **9**, and **10**, but the effects are intensified by the long soaking or annealing for 12 hours, the cementite and pearlite being very well defined in **10**. In all the specimens which have been described the white parts represent ferrite and cementite respectively, and the darker parts the pearlite.

Malleable Iron. Malleable iron castings consist of white cast iron which has been subsequently annealed in iron boxes packed with hæmatite. The carbon in the castings before annealing is chiefly in the combined form, as cementite, and this undergoes a more or less complete change in the process of annealing. Some of the carbon is removed, but the greater part remains as graphite. On the outside of the casting the carbon is oxidised by the oxygen of the hæmatite, leaving ferrite. On the other hand, there is a store of carbon towards the centre of the bar in the form of amorphous graphite, which is continually re-

carburising the ferrite by solid diffusion. The structure of the outside, intermediate and centre of the casting, is seen in 11, 12 and 13.

Copper. The micro-structure of copper varies with the mode in which it has been produced. Electrolytic copper is confusedly crystalline. Pure copper consists of irregular-shaped crystal grains with very fine and sharp boundaries. These crystal grains increase in size according to the slowness of cooling Small secondary grains are often built up from the larger ones. Fig. 14 is the top of a button of copper. When copper is rolled or hammered, as in 15, the secondary grains are elongated in the direction of the rolling, and finally may become so attenuated as to break down. Annealing tends to release the strain and allows the grains to rearrange themselves. Fig. 16 is copper foil, etched in nitric acid, and shows fine elongated grains.

Tin. When an ingot of pure tin is cast it shows a bright surface, but if impure, the surface shows a structure of dendritic crystals. If the surfaces of the ingots be etched, they are seen to be coarsely granular. Fig. 17 is from the base of a very thin sheet of tin cast on stone. Fig. 18 shows a piece of hammered tin, by oblique illumination, etched with dilute nitric acid. The original structure has disappeared, and a finer crystallisation has taken its place. Annealing causes a growth of the crystals. Fig. 19 shows the structure of tin after annealing.

Zinc. An ingot of zinc shows dendrites similar to those of lead and tin. Fig. 20 shows part of a dendrite on the surface of metal cast on stone. There are three main axes.

Aluminium. On the sides and base of a bar of aluminium, where it has cooled in contact with the mould, dendrites of a leaf-like form are seen, and in 21 are several of these dendrites which are the centres of crystallisation.

Lead. Cast lead exhibits a dendritic structure, and the dendrites are the skeletons of grains or primary crystals. In 22 the secondary crystals are seen. This surface was the last to solidify in an ingot cast in stone. Etching brings out the primary crystallisation very distinctly.

Platinum. Fig. 23 shows dendrites on the surface of a platinum button. They consist of two axes at right angles, and form skeletons of the crystals, as in the case of the metals mentioned above.

Silver. Fig. 24 shows the surface structure of an ingot of silver. Three or more primary crystals are seen to be built up of numerous secondaries, possessing distinct orientation.

Gold. Pure gold crystallises in hexagonal crystals, which are built up of secondary crystals. Fig. 25 shows some of the dendrites met with in a slowly-cooled gold button. Rolling breaks down the primary crystals, producing a finer structure.

Alloys. When two or more metals are made to unite permanently, the resulting body is termed an *alloy*. When mercury is the chief constituent the alloy is termed an *amalgam*. Comparatively few of the metals possess such properties as render them suitable to be used alone by the manufacturer, but most of them have important applications in the form of alloys.

The condition of an alloy in the liquid state may be (1) either a solution of one metal in another; (2) a chemical compound; (3) a mechanical mixture; (4) a solution or mixture of two or all of the above; and similar differences may obtain in the solid state. A solidified solution is illustrated in the alloys of lead and tin. Copper and tin produce a chemical compound ($SnCu_3$). Lead and zinc form an example of a mechanical mixture.

The general effect of alloying metals together is to increase the hardness, lower the melting point and conductivity, and otherwise to modify the properties of the separate metals. An illustration of the hardening power by alloying is seen in the case of standard gold and silver; of the lowering of the melting points, in the case of fusible alloy; and the class of alloys known as brass forms a good object-lesson in varying changes of colour produced by alloying.

Properties of Alloys. Metals may be perfectly alloyed together when in the liquid state, but when poured into a mould there is often a tendency for the constituents to separate, causing the mass to be non-homogeneous. The reason of this is that the addition of one metal to another produces an alloy, the solidifying point of which is often lower than it should be according to calculations based on the fusing points of the separate metals. One particular mixture has a lower fusing point than any other possible mixture of the metals employed, and this is termed the *eutectic alloy* of the series. Apart from true chemical compounds, a fluid mixture of two metals begins to deposit its less fusible constituent first, and as the temperature falls, more and more of this constituent will be deposited, the other elements remaining in the fluid portion until it has acquired the eutectic composition, when it will solidify as a whole in the spaces left between the already solidified particles.

The more slowly an alloy solidifies, the greater will be this tendency to separate into two or more portions. Separation in the early stages of cooling may be partially prevented by mechanical agitation, such as stirring with a rod and by pouring into a cold mould. In some cases the difference in the fusing points of the general alloy and the eutectic is so great that they may be largely separated from each other by pouring off the still liquid alloy after the other portion has solidified. An alloy of silver and lead may be separated from copper in this way.

Preparation of Alloys. The usual method of preparing alloys is to melt the metals together in a crucible or furnace, but they may in some cases be produced by strongly compressing the metals together in the form of powder. Certain alloys, such as gold and copper, or copper and zinc, may be made by electro-deposition. Large quantities of alloys, chiefly those of iron and the rarer metals, are made in the electric furnace. Aluminium alloys are also made in this way.

By the thermal method it is usual to melt the metal of highest fusion point first, and then to add the other constituents. Brass, consisting of copper and zinc, may be taken as an example. The copper is melted first because it has a much higher melting point than zinc, and the latter is also very volatile.

Alloys generally have properties differing from their constituents, and some alloys have these differences very strongly marked. Thus, if a very small quantity of arsenic be added to tin, the resulting alloy will have a crystalline fracture closely resembling zinc. Sometimes metals combine with evolution of heat, and sometimes with an absorption of heat. The following metals evolve heat when they are united—aluminium and copper, platinum and tin, arsenic and antimony, bismuth and lead. On the other hand, lead and tin when they unite absorb heat. Metals are capable of diffusing into each other if one of them be kept melted and the other in the solid state. Thus, if molten lead be kept in contact with gold or platinum, some of the gold or platinum will pass into the lead, and some of the lead will pass into the gold or platinum. Similar results occur with tin or bismuth.

Copper Alloys. Copper forms with other metals a numerous series of alloys, and is valuable on account of its red colour, high malleability, ductility, softness, tenacity, and toughness, which properties it imparts in a great measure to many of its alloys. Of these the most important is brass, which is an alloy of copper and zinc. These constituent metals may be united in all proportions, forming alloys of a red or yellow colour, and other properties, according to the amount of copper present. The best varieties are exceedingly malleable and ductile, harder than copper, easily worked, and have a lower melting point and higher tenacity. The composition and properties are shown in the following table:

ALLOYS OF COPPER AND ZINC

Name.	Colour.	Copper	Zinc.	—	Tensile Strength. Tons per sq. in.	Melting Point in Degrees Centigrade.
Gilding Metal	Red	94	6	–	13	1,060
Pinchbeck	Red Yellow	90	8	(Lead) 2	12	1,040
Oreide	,,	90	10	—	12	1,050
Talmi Gold ..	Gold	91	8	(Gold) 1	12·5	1,055
Rich Sheet Brass	Yellow	84	16	—	14	1,015
Bath Metal ..	,,	80	20	—	14	1,008
Dutch Metal ..	,,	76	24	—	13	980
Bristol Brass ..	,,	73	27	—	13	960
Wire Brass ..	,,	70	30	—	13	940
Mosaic Gold ..	Full Yellow	67	33	—	13	918
Muntz Metal ..	,,	60	40	—	20	890
Delta Metal ..	,,	58	39	(Iron) 3	30	900
Sterro Metal ..	,,	56	42	2	—	—
Brass Solder ..	Light Yell.	50	50	—	9	880
,, ,, ..	White	48	52	—	8·5	870
Lap Alloy ..	Grey	12	88	—	2	600

Brass or brazing solders are used for joining parts of brass articles together. The solder must have a lower melting point than the metal to be soldered, and the above table clearly indicates the different temperatures for fusion. Some varieties of brass contain iron, which increases the strength, hardness, and tenacity, but diminishes the ductility.

Bronze. Bronze is an alloy of copper and tin, but lead, zinc, nickel, manganese, iron, or silicon, is often added to produce certain effects, or to reduce the cost. Zinc in small quantities makes bronze harder. Iron and manganese also harden it. Phosphorus and silicon are used as so-called *deoxidisers*, influencing the removal or solution of gases, thus making the alloy more sound and compact, and forming hard, dense, and tenacious alloys. Sulphur and antimony tend to make bronze brittle. Arsenic acts much in the same way as phosphorus.

The physical properties of bronze depend on the composition, mode of manufacture, mechanical treatment, and rate of cooling. Starting with pure tin, the hardness increases with the addition of copper up to 35 per cent., and from this up to 73 per cent. the alloys are exceedingly brittle; beyond this the hardness diminishes as the copper increases. The alloy with 62 per cent. of copper ($SnCu_3$) is distinguished from all the rest by several characters; it presents the same homogeneous composition after repeated fusion, is peculiar in colour, has the highest density, exhibits the greatest degree of contraction, and is so brittle that it can be powdered in a mortar.

Minor Alloys with Copper. *Gun-metal* contains 8 to 11 per cent. tin, and the rest copper, but it frequently contains zinc in addition. *Bell Metal* contains 76 to 80 per cent. copper and 20 to 24 per cent. tin. Small bells are also made of brass. *Speculum Metal* contains 68 to 70 per cent. copper, and 32 to 30 per cent. tin. It is white, takes a beautiful polish, and was formerly used for mirrors.

Special bronzes are made with or without tin. *Phosphor-bronze* is gun-metal to which a little phosphorus has been added. Aluminium bronzes are alloys of copper and aluminium, of which the alloy with 10 per cent. aluminium is the strongest. It has a gold colour, takes a high polish, and is very hard, malleable, and tenacious. The addition of 2 to 3 per cent. of brass increases its tenacity and renders it less liable to oxidation. *Aluminium brass* contains 2 parts copper, 1 part zinc, and 2 per cent. aluminium.

Manganese Bronze is brass to which 2 to 3 per cent. of manganese is added. The manganese in ordinary bronze is added in the form of ferro-manganese. This necessarily adds to the alloy 15 lb. of iron for every 80 lb. of manganese introduced.

Silicon Bronze is ordinary bronze to which 1 to 2 per cent. of silicon is added.

Nickel Alloys. German silver is an alloy of copper, zinc, and nickel. It is used as a substitute for silver, and as the basis of electro-plated wares. The properties which make

German silver so valuable are its white colour, lustre, hardness, tenacity, toughness, malleability, ductility, and power of resisting certain chemical influences. When carefully prepared, it works well under the hammer and stamp and between the rolls, but it is advisable that the metals used in alloying should be as pure as possible, since small quantities of impurities, such as antimony and bismuth, seriously injure its working properties. Cobalt is sometimes added to German silver to the amount of 2 to 3 per cent., and improves the colour of the alloy. The following proportions make good working alloys:

Copper ..	52	54	54	56	58	60	60
Nickel ..	20	18	16	14	12	10	8
Zinc ..	28	28	30	30	30	30	32

German silver is made in crucibles by melting the requisite amount of a 50 per cent. cupro-nickel alloy, and adding the requisite zinc in the form of brass containing equal parts of copper and zinc.

German silver is largely used by electricians for standard electrical resistances because it has a low conductivity, and because the conductivity is not greatly affected by moderate differences in temperature. Platinoid, the electrical resistance of which is singularly constant through considerable ranges of temperature, is a German silver containing 2 per cent. of tungsten.

Cupro-nickel, containing 75 parts copper and 25 parts nickel, is used for small coins, and an alloy of 80 parts copper and 20 parts nickel is employed for making projectiles.

TIN ALLOYS

Britannia Metal	91 Tin	7·5 Antimony	1·5 Copper
Pewter	80 ,,	20 Lead	—
Fine Solder	2 ,,	1 ,,	—
Plumber's Solder	1 ,,	2 ,,	—

LEAD ALLOYS

Type Metal	72 Lead	18 Antimony	10 Tin
,, ,,	82 ,,	15 ,,	3 ,,
Bearing ,,	84 ,,	16 ,,	—
,, ,,	60 ,,	20 ,,	20 ,,
Shot ,,	99·7 ,,	0·2 to 0·3 Arsenic	

BISMUTH ALLOYS

Newton's	50 Bis.	31 Lead	19 Tin	—
Rose's	50 ,,	28 ,,	22 ,,	—
Wood's	50 ,,	24 ,,	14 ,,	12 Cadmium
Lipowitz's	50 ,,	27 ,,	13 ,,	10 ,,

COINAGE ALLOYS

Gold Coin	91·67 Gold	8·33 Copper	(Brit. Standard)
,, ,,	90 ,,	10 ,,	(American ,,)
Silver ,,	92·5 Silver	7.5 ,,	(Standard)

Refractory Materials. When a material is capable of resisting high temperatures without melting, softening, or decomposing, it is said to be *refractory*. Such materials are essential in the construction of furnaces in which most metallurgical operations are conducted; at any rate, refractory bricks and materials are required for the interior, where a high temperature prevails and the scouring action of metallic oxides have to be resisted. Refractory materials are used in the natural state, such as quartz, sand, alumina, oxide of iron, lime, magnesia, and fire clay; or they undergo a preliminary preparation before use.

The degree to which a substance is refractory depends on the circumstances under which it is employed, and chiefly on the substances with which it is brought into contact. For instance, silica (sand) heated alone to a very high temperature does not even soften, but if brought in contact with a base, such as lime or oxide of iron, union takes place with the formation of a fusible silicate. Again, many substances are capable of resisting a very high temperature if gradually raised to it, but have not the power of resisting sudden changes of temperature, as, for instance, when a cold crucible is suddenly placed in a hot furnace.

Silica and Alumina. In the form of quartz, silica is able to resist all ordinary furnace temperatures, and coarse grained sandstones, such as millstone grit, are frequently advantageously used. White sand is very refractory, and is a valuable material for furnace lining, for the beds of reverberatory furnaces, or, mixed with refractory clay, to form silica bricks for the roofs. *Dinas Rock*, found in the Vale of Neath, contains about 97 per cent. of silica, and, when powdered and mixed with a little lime or clay to make it cohere, is pressed into bricks. These resist very high temperatures, and are especially useful for the arches of reverberatory furnaces, as they expand with heat, but they will not withstand the corrosive action of metallic oxides. *Ganister* is another siliceous material, largely used for lining Bessemer converters, and found in the lower coal measures of Yorkshire. It differs from Dinas rock in having the power of binding together when mixed with water. Natural siliceous stones are occasionally used for the hearths of blast furnaces and similar purposes.

Alumina is as infusible as silica, but is rarely found in nature in a pure state. *Bauxite*, which occurs in several localities in France, consists chiefly of alumina and oxide of iron. It is highly refractory, owing to the aluminate of iron that forms at high temperatures being very infusible.

Lime and Magnesia. *Lime and Magnesia* are practically infusible bodies, and strongly basic in character, but readily form fusible compounds with silica. These oxides occur as *dolomite*, from which material the lining of basic furnaces is prepared. *Dolomite* consists mainly of carbonate of lime and magnesia, unlike ordinary limestone or chalk, and after it has been very strongly calcined it can be reheated and cooled as often as required without crumbling. The most successful method of utilising dolomite or magnesium limestone is to fire it strongly, and then to grind it fine and mix pitch with it. The bricks made from this mixture are then strongly fired. Such bricks shrink considerably during firing, which gives them a more or less curved form, and they have to be set with similar material, which is very difficult to fire satisfactorily. In consequence of this, the calcined dolomite and pitch are made

into a "slurry," or liquid mass, and run into a mould of the required size and shape, then consolidated by heat.

Clay. *Fireclay* is essentially a hydrated silicate of alumina, with varying amounts of lime, magnesia, oxide of iron, alkalies, and some free silica. The plastic property which clays possess is due to the chemically combined water. All clays have been derived from the disintegration of felspars, which occur in igneous and some stratified rocks. The character of the clay mainly depends on the nature of the rocks from which it originated, and to the extent to which the felspar has been decomposed. The refractory power depends on its freedom from oxides of lime, magnesia, oxide of iron, and alkalies.

Pure clay may be said to consist of alumina, silica, and water, represented by the formula Al_2O_3, $2SiO_2 + 2H_2O$, or approximately 46 silica, 40 alumina, and 14 per cent. water. The best china clay has very nearly this composition. The composition of fireclay ranges from 50 to 55 per cent. silica, 20 to 32 per cent. alumina, 2 to 4 per cent. lime, magnesia, etc., and 10 to 15 per cent. water. If raw clay be moistened with water, it can be moulded to any desired shape, and preserve its form after drying and baking. If, however, the baked clay be crushed up and again moistened, the plastic property will be found to have disappeared, because the baking at a high temperature has effectually removed the chemically combined water.

Refractory Materials. Refractory materials may be classified as *acid*, such as quartz and Dinas rock; *neutral*, such as graphite and chrome iron ore; and *basic*, such as dolomite, lime, oxide of iron, etc. In furnace construction, a basic material has been found in many cases, especially in steel making, a great advantage for the bed or bottom of a furnace; but basic bricks, as already explained, would not be suitable for the roof arches, because of their contraction on being heated. Hence it is necessary to build the roof with acid bricks. If acid and basic bricks touch each other, a mutual combination is likely to occur at high temperatures, so they are generally separated by a course of neutral material, of which chrome iron ore has been found very effective.

Firebricks are mostly made of fireclay mixed with quartz or burnt clay. The mortar for setting firebricks is prepared from the same materials as the bricks themselves, or from good fireclay, because lime mortar would not be suitable.

Crucibles and Retorts. For certain metallurgical operations, such as the manufacture of cast steel, the extraction of zinc, antimony, arsenic, and mercury, special vessels are employed, in the form of retorts, crucibles, muffles, tubes, etc., and these require to be made for the most part of refractory materials. *Crucibles* are made of fireclay, with sand, burnt clay, or other infusible material, so as to counteract the tendency which raw clay possesses of shrinking when heated. A good crucible should be capable of resisting high temperatures, sudden changes of temperature, and the corrosive action of metallic oxides. It should not be brittle or tender when hot. Some crucibles are required to withstand the corrosive action of metallic oxides, and in such cases the clay should be as neutral as possible, and not contain free silica. In order to test a clay as to its suitability for resisting high temperatures, it should be crushed up fine, sifted, mixed with a proper proportion of burnt clay and water, and kneaded to the right consistency. A piece of the clay is then shaped into the form of a prism or pyramid, so as to form sharp edges, carefully dried, baked and exposed to a high temperature in a covered crucible for some time. If very refractory, the test piece will show no signs of fusion. If the edges have become somewhat rounded it indicates incipient fusion, and if melted, the clay is useless. A similar piece should be tested in a reducing atmosphere by packing it round with charcoal in the crucible. In order to test fireclay as to its resistance to corrosion, the crucible may be half filled with copper, which is then melted, and a little borax inserted, so as just to form a ring round the edge of the molten metal, and yet leave the centre free for oxidation. The borax will absorb the oxide and rapidly corrode the crucible unless it be of excellent quality. The behaviour of the crucible under the weight of the copper melted indicates the other qualities of the crucible.

Plumbago Crucibles. Plumbago crucibles are made of clay and graphite, in the proportion of 51 of the former to 49 of the latter. Only certain varieties of graphite are suitable, the texture being of great importance. The graphite is picked, ground, sifted, and mixed with fireclay, and left for some time to *mellow* after it has been kneaded damp. The crucibles are moulded, dried, then burnt in kilns. An oxidising atmosphere must be avoided to prevent the carbon burning off.

The following analyses show the approximate composition of British materials used in furnace construction:

MATERIALS IN FURNACE CONSTRUCTION

Material.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Potash and Soda.
Firebrick—						
Stourbridge ..	73	22	2·4	0·5	0·5	1
Newcastle ..	73	21	1·7	1·5	0·7	2
Pensher	65	30	2	0·5	0·5	2
Flintshire	88	4·5	6	1·2	—	—
Leeds	77	19	1·4	0·5	0·6	1
Elland	62	35	1·2	0·7	—	—
Ganister bricks—						
Lowood	96	1	0·7	1·3	0·2	0·3
Witton	94	1	1	2·8	0·3	0·3
Dinas bricks—						
Wales	96	0·5	0·3	3	0·3	—
Burnt Dolomite—						
Raisby Hill ..	6	2	1·7	57	32	1
Ganister—						
Lowood	89	5	1·3	—	0·8	3·5
Weardale	88	9	0·7	0·6	0·4	1·6

Continued

THE MYSTERY OF THE N-RAYS

Continued from page 3852

Do the N-rays Exist? The Mysterious Discovery of M. Blondlot. The Fallacy of Human Vision. The Doubtful Result of the Camera. Prof. Rontgen and the X-rays

By Dr. C. W. SALEEBY

The Unity of Ethereal Vibrations. Everything goes to show that the one ether is adequate, as Faraday expected, for the explanation of light and of electromagnetic phenomena. Says Clerk-Maxwell: "The properties of the electromagnetic medium are therefore, as far as we have gone, similar to those of the luminiferous medium, but the best way to compare them is to determine the velocity with which an electromagnetic disturbance would be propagated through the medium. If this should be equal to the velocity of light we should have strong reason to believe that the two media, occupying as they do the same space, are really identical." We now know that, as Hertz proved, the two velocities are equal. Again, Clerk-Maxwell goes on to recount a number of difficulties which lie in the way of the acceptance of "the undulatory theory, in the form which treats the phenomena of light as the motion of an elastic solid." We cannot do better than quote his own words:

"The first and most important of these (difficulties) is that the theory indicates the possibility of undulations consisting of vibrations normal to the surface of the wave. The only way of accounting for the fact that the optical phenomena which would arise from these waves do not take place is to assume that the ether is incompressible.

"The next is that, whereas the phenomena of reflection are best explained on the hypothesis that the vibrations are perpendicular to the plane of polarisation, those of double refraction require us to assume that the vibrations are in that plane.

"The third is that, in order to account for the fact that in a doubly refracting crystal the velocity of rays in any principal plane and polarised in that plane is the same, we must assume certain highly artificial relations among the coefficients of elasticity.

"*The electromagnetic theory of light satisfies all these requirements by the single hypothesis that the electric displacement is perpendicular to the plane of polarisation.*"

New Kinds of Radiation. We must now turn from this theory of light, which completes, perhaps, a magnificent train of optical discoveries made in this country from the time of Newton onwards, and must consider one or two kinds of radiation, the very existence of which was unsuspected until recent times. Of these, by far the most important are the Röntgen rays, which have proved themselves to be of such very great practical importance. But in the first place we may address ourselves to the so-called N-rays which are sometimes named after their discoverer, M. Blondlot, of the University of Nancy, in France.

Did M. Blondlot See the N-rays? Let us begin in the first place by noting that some measure of doubt still exists as to the objective actuality of these rays. M. Blondlot has a sound reputation as a physicist, and there is no suggestion of fraud in his assertions, but for some reason or other there has been very great difficulty on the part of other men of science in obtaining the results which M. Blondlot believes himself to have obtained. M. Blondlot worked at the subject for three years before he made any announcement. A number of French physicists confirmed the discovery, and a continuous flood of papers on the subject poured into the Paris Academy of Sciences for some time. The N-rays were promptly hailed as proof of "telepathy," and it was hoped that, since they are said to be specially emitted by active nervous tissue, they might be utilised in medicine. The Blondlot rays are said to pass through aluminium or black paper, and, according to these observers, can be focused by an aluminium lens just as rays of ordinary light can be focused by a glass lens. They seem to be emitted by almost all kinds of matter—and ceaselessly so. Professor Charpentier, of the Chair of Physiology at Nancy, declares that these rays are given out in special degree by living muscle and nerve. According to him it is possible, by using means to identify these rays, to trace the course of relatively superficial nerves in the forearm, such as the median nerve; and it is found that the amount of radiation increases when the nerve is at work.

"Spectral" Rays. It would evidently be hasty, however, to assume at once that the discovery of these rays establishes an epoch in the study of telepathy, because there is no essential distinction between these supposed Blondlot rays and the rays of radiant heat which are also emitted by nervous tissue. The N-rays are said to include at least four sets of rays of slightly different properties, just as the octave of visible light includes many different colours. They are definitely asserted to be spectral rays—that is to say, to lie in the ethereal keyboard, and not to be, in reality, material like the so-called alpha rays of radium. It is asserted that they can be reflected, refracted, and polarised just like ordinary light, and that their wave length is measurable.

It was next shown, according to the French observers, that under certain other conditions a closely allied set of rays could be discovered, and these are known as the N_1-rays. And it seems to have been shown that, in the first place,

nervous structures exceed all other substances, organic or inorganic, in their emission of the N and the N_1-rays; and, secondly, that the application of anæsthetics arrests the production of both by nervous tissue. It was at this stage in the history of the subject that the Paris Academy of Sciences, a body comparable in dignity and knowledge to our own Royal Society, awarded to M. Blondlot the Le Comte prize of 50,000 francs for the most interesting work in physical science (July, 1904).

Are the N-rays a Myth? A few months later the editor of the "Revue Scientifique" instituted an inquiry into the subject. He addressed questions to all the leading physicists in France, including such men as Becquerel, Berthelot, Moissan, d'Arsonval, and Professor Curie, whose recent death is to be deplored by all students of science. Now, if there is anything quite certain it is that no scientific question nor any other matter of truth or falsehood can be settled by a counting of heads. But, nevertheless, the opinions of men such as these are worth noting. The inquiry was well timed, for the question had become acute. A well-known Anglo-Saxon physicist had visited the laboratory at Nancy and could see nothing. He wrote a letter to "Nature" saying so. Also the subject was discussed during an entire sitting of a section of the British Association in 1904, and the general opinion arrived at was that the N-rays are a myth.

The result of this notable inquiry was most interesting, and may be typified by the translation of parts of two consecutive answers. M. Poincaré said: "I have made researches which have not given me results"; and M. d'Arsonval said: "I have made some trials which have perfectly succeeded."

Can We Believe Our Own Eyes? Of course, such differences of opinion as these give the enemies of science occasion to blaspheme. They say that if scientific methods are worth what they are said to be worth they should be able to solve such a simple question as this; but, as the present writer has pointed out elsewhere, "no matter is simple that involves anything so infinitely complex as human vision." M. Poincaré, for instance, goes on to say that he has a spasm of accommodation (that he is unable to relax the internal muscles of the eye, so as to focus it for distant objects); and it is asserted that one cannot observe these phenomena unless the accommodation be relaxed. This argument will appear quite reasonable to anyone who has tried to look into the interior of an eye with the ophthalmoscope, when it is essential for success (by the direct method) that the accommodation be relaxed, as if one were gazing at the horizon, though one is really trying to see an object not two inches distant. Then, again, it is perfectly well known, in the case of the sense of hearing, that different people have different capacities. Some can hear the shrill cry of a bat, while others cannot. Without doubt, the same is true of the visual sense. There may be very few eyes that happen to be capable of seeing these phenomena.

Sources of Fallacy. But this is by no means all. It is notorious that when experiments are repeated under what purport to be the original conditions, but without producing the original result, it is often found that the conditions have not really been similar. If the one experiment has been made in a room whose temperature was 60° F., while the other was five degrees warmer, the discrepancy may be accounted for. Frequently the discovery that such minute conditions are potent has led to important results. Then, again, if we assume that the N-rays have no objective existence, but are simply due to peculiar happenings in the eyeball of the observer, we have not yet explained why some observers obtain the results and others do not. Does not this immediately show that eyes vary?—which is what those who believe in the rays very properly assert.

There remains bad faith, which can be excluded in this case, and the influence of what the psychologists call *suggestion.* It may be that, especially perhaps in people with a French temperament, those who see the rays are those who believe most strongly in M. Blondlot's ability, and conversely.

From just about the time that the "Revue Scientifique" published the result of its inquiry, the flow of papers on this subject to the Paris Academy of Sciences ceased; and for a very considerable time practically nothing whatever was heard of the N-rays.

Evidently it is the photographic camera that should settle this question, once and for all, as it has indeed settled the parallel question of the canals of Mars. And quite recently, when many had almost forgotten all about the N-rays, they "turned up again." Photographic evidence was brought forward. The N-rays do not directly affect a photographic plate, any more than they directly affect the eye. The question all along has been whether the production of these rays really affects other luminous bodies, altering their brightness in the fashion which, as M. Blondlot asserts, can be readily seen by the eye.

Have the Rays Been Photographed? It now appears that the observers at Nancy have succeeded in photographing the result of the production of N-rays under certain conditions. Nevertheless, this question seems to be still destined for the production of doubt, and highly competent observers are now to be heard saying that when they repeat in every particular—apparently—the Nancy conditions, they do not obtain the photographic results which were there obtained. Hence it is impossible even yet to say for certain whether or not the N-rays are a reality. On the whole, perhaps, recognising the superior value of well-attested positive evidence, as against equally well-attested negative evidence, and remembering also that there is no inherent improbability, but rather the utmost probability, in the asserted existence of these rays, we may tentatively incline to the view that their objective reality will shortly be demonstrated. It would surely seem incredible that the present gaps in the ethereal keyboard, as we know it, correspond to actual gaps in

Nature; nowhere will there be found a physicist to doubt that from the longest electric waves—perhaps half a mile in length—up to the Röntgen rays, the length of which must be measured in millionths of an inch, there is perfect continuity. The assertion of M. Blondlot is no more than that he has discovered the means of production, and has detected the consequences, of certain of the rays, as to the necessity of the existence of which we all agree.

The Interpretation of Nature. "Man," said Bacon, "is the servant and interpreter of Nature," and Science, properly so-called, is not observation or experiment or calculation, but interpretation. The greatest of the names which have been mentioned hitherto in this course, and the greatest names in all the sciences, are not, after all, necessarily the names of the greatest observers or the most ingenious and patient experimenters; they are the names of the interpreters. The main principles on which we act, according to Bacon, in attempting the interpretation of Nature, are discussed in another course. But this present controversy about the N-rays affords a particularly instructive instance of the actual difficulties that may beset us.

In interpreting the facts, or alleged facts, before us, we may be tempted in this case, as we are tempted, indeed, at all times, to assume that the explanation must be either A or B, or perhaps A or B or C. We then proceed to exclude each of these factors in turn until, having successfully excluded A and B, perhaps we can rest content in the belief that C is the true explanation. Now, the process of exclusion is an absolutely valid and efficient one if our assumptions are sound, but it leads to the most unfortunate consequences if they are unsound. The commonest defect of such assumptions is the omission of possibilities. For instance, if there be a fourth possibility, D, which we ignore, our inference from the exclusion of A and B—*viz.*, the inference that C is the correct explanation—plainly ceases to be valid.

The Possible Explanation of the Mystery. Now let us apply this to the present case. The more we think about it, the greater is the number of possibilities which we discover. It has been the particular endeavour of the writer to enumerate as many possibilities as he can, but he has no doubt whatever that there may be others—perhaps many others—which he has not recognised. Either (1) the phenomena asserted to have been seen by M. Blondlot have an objective existence; or (2) they have not. First, considering the latter possibility, we find a number of possible explanations of M. Blondlot's assertions: (1) That he is self-deceived; (2) that he is consciously dishonest; (3) that he and his fellow-workers are the victims of mutual suggestion; (4) that the eyes of M. Blondlot and those who have seen these phenomena differ in some specific way from the eyes of those who have failed to see them.

On the other hand, various possibilities may be assigned on the assumption that the N-rays have an objective existence: (1) That those who have denied their existence are dishonest; (2) that they are self-deceived; (3) that, in various attempts to confirm M. Blondlot's results, all the conditions have not been reproduced, even though all that he himself names have been reproduced. There may be other conditions which he himself has not recognised, but which are present in his experiments, are necessary for the production of the N-rays, and, as it happens, are not present when proof of the existence of these rays is sought for elsewhere than at Nancy.

We would appear to have completely exhausted, or more than exhausted, all the possibilities which have to be reckoned with if this problem is to be solved by the "method of exclusion." Yet there actually remains a possibility, which many will have forgotten, and which is not included in either of the two simple propositions with which we began. Perhaps it is quite possible that the N-rays have not an objective existence in the sense in which we have used the words, and yet that they have an objective existence. Nothing could appear fairer or more final than the simple alternative with which we started, and yet it was false, for it totally omitted to recognise the possibility that the so-called N-rays may be none other than the manner in which certain persons under certain conditions can appreciate some internal phenomenon of the retina. Is such a phenomenon objective or subjective? The student of psychology cannot fail to answer that it is really objective, but then he has looked rather more deeply than most of us into the proper meaning and use of those adjectives. Such vision is now known as *entoptic vision*—that is, vision of what is *within the eye.*

Professor Röntgen and the Röntgen Rays. The remarkable Röntgen rays which we are about to study are very frequently known as X-rays, this being the name which was given them by their discoverer, obviously with the intention of indicating their unknown character. But in the last decade physical science has moved by tremendous strides, and the nature of these rays is no longer unknown. There are sufficient phenomena in Nature indeed to which the term X may well be applied, and it is surely a pity that we should not now always use the name of the discoverer to indicate these remarkable manifestations of energy.

Professor Conrad Wilhelm Röntgen made his great, if somewhat fortunate, discovery on November 8th, 1895. The date is really a memorable one because of the amazing impetus which this discovery imparted to the progress of physics. Professor Röntgen still flourishes, and was the subject of a celebration held in Berlin last year in honour of the completion of a decade since his first observation. He was undoubtedly fortunate in not being anticipated by Sir William Crookes, after whom the Crookes or vacuum tube is named, for these tubes had actually been in general use, mainly for purposes of demonstration, for considerably more than twenty years before 1895. Dr. Hertz also, to whom we have already referred, had all but completed the observation of these new rays.

Continued

THE ART OF NORTHERN EUROPE

Renaissance Architecture and Sculpture outside Italy. Elizabethan Architecture. Wren. Painting in Flanders and Holland. The Van Eycks. Rubens and Rembrandt

By P. G. KONODY

Renaissance Blending with Gothic. Just as the Gothic style, born in the North, found the Italians reluctant to accept its tenets, so Renaissance architecture could only slowly force itself upon the Northern nations. In France and in Germany the new forms made their appearance comparatively late in the sixteenth century, and to a great extent lost their original purity through combination with Gothic motifs. The church of St. Eustache (A.D. 1532), in Paris, illustrates the blending of the two styles, and such French private buildings as the castles of Chenonceau and Chambord show the picturesque combination of Renaissance motifs with Gothic turrets and slanting roofs. One of the most graceful structures of the Renaissance in France is the famous winding staircase at Blois, which a recent critic has tried to prove to be designed by Lionardo da Vinci [see pages 3244-5]. The Louvre, the Luxembourg, the Panthéon, and the Dome des Invalides in Paris, are notable examples of the French Renaissance. In Germany the castle of Heidelberg (A.D. 1545) is a remarkable instance of the blending of Classic decoration with Gothic sentiment. But in both countries the new style did not achieve complete victory before the seventeenth century, when its severe beauty had given way to the flamboyancy of the Baroque.

In England, the introduction of the Renaissance style is due to Italians, such as Torrigiano, the designer of Henry VII.'s tomb in Westminster Abbey, John of Padua, Giovanni da Majano, and Rovezzano.

Elizabethan Work. The Elizabethan style, "an attempt on the part of the English to translate Italian ideas into their own vernacular," was chiefly employed for richly-decorated private mansions and dwellings, of which we need only mention Longford Castle, built by John Thorpe; Knole, Kirby, and Penshurst. In the Jacobean period the Renaissance character became more pronounced, especially in the use of columns and entablatures. Holland House and Hatfield House may be quoted as notable examples. But Elizabethan and Jacobean buildings on the whole only form a transition from the Gothic to the pure Renaissance style, which appeared, with Inigo Jones, in the seventeenth century. This master's great buildings, such as the Banqueting Hall, Whitehall, and the Duke of Devonshire's villa at Chiswick, prove him a student and follower of Palladio. Inigo Jones was followed by Sir Christopher Wren, the builder of St. Paul's and several other beautiful churches. He died in 1723.

Northern Renaissance Sculpture. The progress of sculpture in Northern Europe cannot be followed as easily as in Italy, for in spite of the colossal output of artistic work in France, Germany, and the Netherlands there is a lack of brilliant individualities which stand forth as landmarks of the progressive

Mansell

77. THE CENTRAL PORTION OF "THE ADORATION OF THE LAMB," BY HUBERT AND JAN VAN EYCK
(Church of St. Bavon, Ghent)

stages of development. Local schools there were in vast numbers, and throughout these countries the same tendency is to be noted; but few, indeed, are the men whose names have been handed down through the ages as creators of masterpieces. Love of carefully-studied detail, clear rendering of facial expression, close adherence to nature, and delight in rendering the various textures, are the chief characteristics of Northern Renaissance sculpture, which could never rival the triumphs of Italy, partly owing to the lack of classic examples, partly to the absence of the suitable material — the marble of which the Italians had an abundant supply.

78. "THE DESCENT FROM THE CROSS," BY RUBENS
(Antwerp Cathedral)

Wood-carving in Germany. During the fifteenth century the art of wood-carving reached an extraordinary degree of perfection in Germany. The tendency of the carved wood statues and altars with many figures in high relief, was distinctly pictorial, especially in the restless arrangement of the draperies; and painting and gilding were frequently resorted to to enhance the effect. Nuremberg at that time became the chief centre of German arts and crafts. It is almost essential to visit this quaint old-world city to form an adequate idea of the art of this period, for it harbours the chief works of such masters as Veit Stoss, the wood-carver; Adam Krafft, the stone-sculptor; and Peter Vischer, the bronze-worker, who is the author of the famous figure of King Arthur in the "Hofkirche" at Innsbruck.

Sculpture in France and England. In France the chief works of sculpture produced between the Gothic period and the triumph of the Italian influence of the masters summoned by Francis I. to Fontainebleau, are to be found among the monumental tombs at Dijon, Amiens, Rouen, St. Denis, and Bourges. Then Primaticcio and Rosso started the Italianising school of Fontainebleau which produced sculptors like Jean Goujon and Germain Pilon. The naive realism of the earlier sculptors had now given way to an elegant and sometimes mannered style, the chief aim of which was decorative effect. The reliefs of the Fontaine des Innocents, at the Louvre, in Paris, represent Goujon at his best; whilst Pilon's Three Graces, likewise at the Louvre, illustrate this master's exaggerated elegance. What little indigenous style there was in English sculpture was stifled by Torrigiano, Benedetto da Rovezzano, and other Italians called to England in Tudor days.

The rise of pictorial art in the North coincides with the invention of oil as a medium for painting by the brothers Jan and Hubert Van Eyck, at the end of the seventeenth century. And curiously enough, Flemish painting, at its very beginning, appears at a stage of development which Italy had only reached by slow and gradual steps. The Van Eycks are great masters, not only by comparison with those that went before, but even if measured by those that followed them. We have already seen how the conditions imposed by the Gothic architectural system limited the painter's activity to small panel pictures, so that his attention was fixed on the elaboration of minute detail, instead of monumental massing of line of form, and on soulful expression instead of stateliness of pose.

Oil Painting in Flanders. The new school arose in Flanders—the Belgium of to-day—which was then one of the chief commercial and industrial centres of the world. The brilliant pageants of the Flemish cities, with their constant coming and going of wealthy traders from every part of the world, must have been a powerful stimulant to the local painters, who had ample opportunities of feasting their eyes on colour, and studying the types and costumes of the seething international crowds that filled the streets and markets.

The Van Eycks. Hubert Van Eyck was born about A.D. 1366, and worked principally at Bruges and Ghent. The subject matter and symbolism of his paintings are still quite mediæval, but the actual incidents, costumes and types, architecture and landscape, are lovingly and faithfully copied from the scenes which he had daily before his eyes, and set down with painstaking precision, which was only surpassed in minuteness by the work of his brother Jan. The "Adoration of the Lamb" [77] is their chief work. Rogier van der Weyden, born in A.D. 1400, was a little less literal in his transcripts of nature, and more emotional in expression. Hans Memline, a Bruges painter of German origin, born about 1430, is the most lovable painter of a school which too frequently delighted in the realistic representation of scenes of tortures and other horrors. In him the realistic tendency of the school finds expression in the wonderful rendering of landscape and accessories, but he was an artist full of tender feeling and poetry, with a rare sense of feminine purity and innocent grace. Gerard David, who was born about 20 years later and worked at Bruges at the end of the century, was much influenced by Memline, and is distinguished by a glowing sense of colour and beautiful line. Quentin Matsys, born 1460, practised portraiture and genre, besides religious art, and marks a decided advance in expressive modelling. With Mabuse, who died in 1532, and even more with his contemporary, Raphael's pupil, Bernard van Orley, the Italian influence begins to filter through the local tradition, and in the case of the latter is to be detected in a more ample sense of design and a departure from the severe exactitude of the earlier masters. But what had been the result, in Italy, of centuries of slow development, could not be transplanted in its mature form to foreign soil, and became mere mannerism with the later Flemings, until a new era of superb artistry dawned with the advent of the great Rubens.

Rubens. Rubens (A.D. 1577-1640), too, had drunk at the same source of Italian art, and his early work in particular evinces his love of Venetian colour, but he brought into his painting a strong, virile, and altogether personal temperament that could never have been content with mannered imitation. A colourist of tremendous power, Rubens excelled above all in the painting of flesh, in which he stands unrivalled to this day. One may be repelled by the coarse, fleshy type of his women, but the mastery with which he expressed with bold, sweeping strokes of luminous paint the roundness of form, the texture of the skin, and the very blood coursing under the skin, irresistibly compels one's admiration. The passionate movement, the vigour and verve of his work, seem to exclude the possibility of a deliberately calculated design, and yet the noble disposition of his figures, the effective massing of light and shade are as "scientific" as the movement and sensuous colour are instinctive. Rubens was the most worldly of all painters, yet he could treat a religious subject with a reverent spirit [78]. He was equally great in portraiture, in genre, in landscape, and in animal painting. But it should be remembered that in accordance with the custom of the period, he had a horde of assistants working under him, and many of the inferior pictures that pass under his name owe to him merely their conception, while the execution is entirely due to his pupils.

Van Dyck. Much the same remark applies to the greatest of his pupils, Van Dyck (A.D. 1599-1641), who, as Court painter to Charles I., exercised so potent an influence on English art that he may rightly be considered the real founder of the great English school of portraiture. Indeed, many of the paintings turned out from his studio at Blackfriars during his English period are the work of his numerous assistants, save for the first sketch and the finishing touches. Van Dyck, too, studied for some years in Italy, where, like his master, Rubens, he fell under the spell of the Venetians. An accomplished courtier and man of the world, he became the favourite of society in his native country, as in Genoa and in England. His pictures are a perfect mirror of the English aristocracy of his day, reflecting their taste and distinction and effeminate elegance. As a colourist, he was more subtle and refined, if less vigorous, than Rubens.

79. "THE DELIVERANCE OF ST. PETER," BY TENIERS THE YOUNGER
(From the Wallace Collection, London)

The coarser side of Rubens's art attracted Jacob Jordaens, whose lack of refinement is scarcely atoned for by his great technical skill and good humour. Franz Snyders (A.D. 1579-1657) was a brilliant animal painter, whilst Jan Fyt and Jan Weenix excelled in still life, generally of dead game. Melchior Hondekoeter devoted himself almost exclusively to the bird life of the farmyard. All these masters were great colourists, and stand supreme, each in the narrow range he imposed on his art.

Growing Popularity of Art. The earliest Dutch painters, among whom Dierick Bouts and Lucas van Leyden are the most

prominent, were almost completely dominated by the genius of the Van Eycks and the other early Flemings. In fact, in their early stages, the two schools can scarcely be considered separately. Then came the Reformation and the War of Independence, which resulted, in 1648, in the final shaking off of the Spanish yoke. The long period of warfare and bloodshed was not favourable to extensive art production, but when Protestant Holland issued victorious, a great period of art commenced—of art led into new channels, since Protestantism looked askance at religious painting, and preferred bare, whitewashed walls in the churches to an imagery of glowing colour. On the other hand, a demand for art arose in the civic community. The well-to-do citizens enlisted art for the adornment of their living rooms, and the subjects favoured were no longer, as may well be imagined, flagellations and crucifixions, and images of the Virgin and saints, but portraits, landscapes, genre scenes depicting the daily life of the burghers and peasants, and, for the guild halls and other official buildings, large portrait groups of prominent burghers.

Pictures in the Dutch Home. Of idealism and ideology, there is little or nothing in Dutch art which is entirely based on love of nature and on the keen appreciation of the value of pigment. The rich quality of the paint, the subtlety with which the play of light and shade on objects and textures is observed—these were the chief points that appealed to the Dutchmen. These little genre scenes—interiors of burghers' houses, with ladies before a mirror, or occupied with books or musical instruments; or tavern scenes depicting the life of the humbler classes—are never of anecdotal or literary character; they are just glimpses of real life stated in terms of ornamental craftsmanship. Of this nature are the precious gemlike pieces of Terburg, Vermeer van Deft, Metzu, Jan Steen, Mieris, Gerard Dow, and, in Flanders, of the Teniers, who had more in common with the Dutch "small masters," than with the Flemings. Fig. 79 is an example by the younger Teniers.

80. "ST. MATTHEW," BY REMBRANDT *Mansell*
(The Louvre, Paris)

Frans Hals. But the seventeenth century small masters were preceded by a few men who must rank among the very giants in the realm of painting. Rembrandt is one, and by no means the least brilliant, of the great triple constellation that stands out from the firmament of art, the compeer of Velasquez and Titian. Before him, Frans Hals (A.D. 1584-1666) had achieved the greatest triumphs in bold, daring portrait painting. For sheer bravura and dashing brushwork and brilliant characterisation, Hals has probably never been equalled, and his large "Doelen" groups at Haarlem are an inexhaustible source of delight to all who can appreciate masterly brushwork. Then, Van der Helst (A.D. 1613-1670) may be taken as the most capable of the numerous serious portrait painters who recorded with faultless conscientiousness in a somewhat tight manner the features of civic dignitaries and their buxom housewives.

Rembrandt the Revealer. But with Rembrandt (A.D. 1606-1669), all hardness, one might almost say all linear design, was abandoned, and everything that the artist's eye could see, or his brain conceive, expressed in terms of soft lights and shadows and golden, liquid half-shadows. Everything is given plastic form through the play of light on the surfaces which are seen through the surrounding atmosphere [80]. In his golden illumination and forced contrasts, Rembrandt is, perhaps, not always strictly true to nature, but he has the power to make us feel that, if such conditions of light were possible, faces and objects would appear just as he has set them down [see "The Night Watch," reproduced on page 724]. Rembrandt is the antithesis to the Italians of the Renaissance, who were ever striving for beauty. With him character is everything, but the mastery of his brush and his sympathetic insight into the very soul of his sitters give beauty even to subjects repellent in themselves. Apart from his paintings, Rembrandt's etchings alone would entitle him to one of the most exalted positions among the world's great artists. As a master of the burin he has never been approached.

Continued

HARMONIUM & AMERICAN ORGAN

Character and Mechanism. The Stops. Practice and Exercises. Keyboard Study. Fingering

By J. CUTHBERT HADDEN

THE harmonium, in common with several other instruments, traces its origin to the invention—speaking more correctly, to the revival—of the free reed. The free reed is so ancient that they say it was employed for musical purposes in the time of Confucius. At any rate, its revival in Europe dates only from the beginning of the nineteenth century; and the harmonium was the instrument in which it was most effectively revived. The sounds of the instrument are produced entirely by these reeds—thin tongues of metal set in motion by currents of air from the wind-chest; called reeds because they correspond in principle with the shepherd's pipe; *free* reeds, because the tongue moves freely in the orifice of the frame, thus differing from those of the organ, which strike against the frame at each pulsation, and are termed *beating reeds*.

The Youngest Keyboard Instrument. If we except the American organ, the harmonium is the youngest of all keyboard instruments. Though it had several tentative predecessors, it may be fairly said to have been invented and first brought out by M. Alexander Debain, of Paris, whose patent was dated August 1840. Since then it has been successfully improved by various makers, mostly French, until, in the best specimens of its class, we have now an instrument of the utmost possible perfection. Its capabilities are considerable. For accompanying voices, for church and domestic purposes, for solo work, for duet playing with other instruments, such as the piano, it is invaluable. The variety of beautiful effects and the delicate shades of tone-colour which may be produced on a good and fairly large instrument not even the organ itself can excel.

By the use of the *Expression* stop, for example, the harmoniumist gains a power of increase and decrease of sound almost equal to that which the violoncello player secures by means of his bow. The harmonium is often regarded as a long-suffering, unpopular instrument. This is really because there are so few who are capable of handling it to advantage. The pianist is supposed to be able to play it without any special study; the organist, too, as a matter of course. Here is the cardinal mistake. The harmonium must be studied by and for itself.

The American Organ. It will be seen that we have bracketed the American organ with it. Rightly so, for the keyboards of both instruments are practically identical, and the method of playing both is entirely identical. It is only in their internal construction and in the quality of tone produced that the two instruments differ. In the harmonium the wind is forced *through* the reeds, while in the American organ it is *drawn in*. It is this that accounts for the more delicate tone of the American organ as compared with that of the harmonium; which instrument, however, has more character and greater distinctiveness, besides being more quickly responsive to the finger of the player. For solo purposes the American organ is of great use, the stops in the right hand being well suited for giving prominence to a melody, while in good instruments the left-hand side always furnishes one or more soft stops for accompaniment. About the tone, as a whole, there is a more general approximation to that of the church organ than in the case of the harmonium. It is therefore more peculiarly adapted for sacred music, and perhaps also for chamber or domestic use.

But the harmonium has much more "carrying" power, and is thus specially suitable for conditions to which the American organ cannot be so well applied. As one of its advocates has put it: "Where a large number of voices are to be accompanied, or where power and marked delivery are called for, in church, concert, or school work, the harmonium, not to speak of its superior hardiness, possesses immense advantages over the American organ." It is, then, the harmonium that we deal with specially in these lessons, which, however, so far as playing is concerned, are equally applicable to both instruments. When points of difference arise as regards the treatment of the individual instruments, they will be carefully explained.

Buying an Instrument. Perhaps, before going further, a word or two should be said about the purchase of an instrument. Small harmoniums and American organs can be had for £5. Many (not all) of these are quite good enough for the learner's purpose. Larger-priced instruments simply mean more stops; which, again, mean only more variety of tone. To the learner, variety of tone is not essential—he does not know how to use it to advantage—and, if money is a consideration, he need not hesitate to buy an instrument at the price just named, provided it is by a maker of some standing. Naturally, we cannot advertise names here. We can only advise the student to go to a firm with a reputation for honourable dealing, state the price he is prepared to pay, and make his own selection from the instruments submitted to him. Beware of "bargain" instruments advertised to be sold "at a sacrifice." Large firms have always a number of second-hand instruments for sale—instruments that have been out on hire or taken in exchange—and a capital instrument, a genuine "bargain," may often be got in this way for a comparatively small sum. Be sure, at any rate, that you

secure an instrument with a tone that pleases you. A harsh, unmusical chest of reeds will soon disgust you, besides having a deteriorating effect on your ear. Thus, on every ground, it is advisable to put yourself in the hands of a trustworthy expert with a reputation to sustain.

The Mechanism. Now we are ready to give our attention to such of the mechanism of the harmonium as it is expedient for the student to be acquainted with before beginning actual work at the keyboard. We have spoken of the reeds, termed now more generally *vibrators*. Well, to every digital on the keyboard there is a separate vibrator, and a harmonium must always have at least one full row of vibrators. Instruments with six and seven sets of vibrators are common; those with eight or more often have two keyboards. We shall learn further about this when we come to deal with the stops.

The external mechanism may be said to be represented by the foot-pedals for blowing. By these the bellows are fed; they force the air through the wind-trunk into the wind-chest, from whence (if the Expression stop is not drawn) it proceeds to the reservoir in an equal and continuous stream. When the Expression stop is drawn, all communication between the wind-chest and the reservoir is cut off, so that the air goes straight to the reeds. It is thus directly under the control of the player, whose least change of pressure upon the foot-pedals produces a like change in the strength of the sounds. It is important that the student should note this, for the Expression stop (more will be said about it) is the most difficult piece of mechanism to manage in the harmonium, and an ill-regulated use of it may easily damage the instrument.

The Stops. Under the head of mechanism we may fairly consider the various stops. We will take the harmonium alone here, for in this matter of stops the American organ differs. Makers, unfortunately, do not agree as to the nomenclature of every stop placed in their harmoniums. In most instruments, however, the first four stops on each side will be found to correspond. They are as follow:

Left-hand Side	Right-hand Side
① Cor Anglais	① Flute
② Bourdon	② Clarinette or Clarionet
③ Clarion	③ Fifre or Fife
④ Bassoon	④ Hautbois or Oboe

The numbers, you observe, are repeated on both sides. Why? Because each stop goes only half way. Thus, if you draw a stop on the right-hand side without drawing anything on the left-hand side, you will get no sound below F at the middle of the keyboard. In reality, therefore, though you have on your instrument the eight stops enumerated above, you have only four separate kinds of sound.

Division Stops. It may be asked why one stop should not be made complete—to run from end to end of the keyboard? The reason is that it is not always necessary or desirable to have the same kind of tone in both treble and bass. For instance, a melody may be played on the *Hautbois*, and accompanied with the left hand on the *Cor Anglais*; or a tune may be "brought out" in the bass on the *Bassoon*, with a light right hand accompaniment on the *Flute*. This will be better understood when we come to speak of the combination and individual tone qualities of the stops.

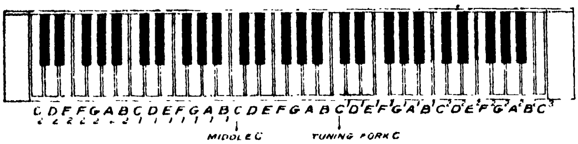
In addition to the sounding stops enumerated above—and others found in large instruments—there are usually six stops of a purely mechanical nature. One is the *Expression* stop, already mentioned. Another is the *Grand Jeu*, which brings out the full power of the instrument at once—in fact, all the stops. Then there is the *Sourdine*, assigned to the bass part of the *Flute* stop. It regulates a contrivance whereby a smaller quantity of wind is supplied to the reeds, thus modifying the strength of the tone. The *Tremolo*, again, alternately opens and closes the wind-chest, thus producing the effect from which it takes its name. Finally, there are the two *Fortes*—one for each side of the instrument—which simply increase the volume of sound by the opening of a sliding or revolving wooden shutter above the reed. Thus provided with mechanical stops, our original instrument, as above, mounts up to the imposing total of fourteen "knobs."

American Organ Stops. In the American organ one or two of the harmonium stop-names are repeated, but the names are, as a rule, peculiar to the instrument itself. In the harmonium the arrangement and naming of the stops are—as regards the first four on each side, at least—practically stereotyped. In the American organ, on the other hand, you can never be sure of what you have on any particular instrument till you examine it. The diversity is indeed so great, different makers using a nomenclature according to their own fancy, that any attempt at an ordered list of stops would be futile. Generally speaking, however, the *Melodia* and the *Diapason* correspond to the *Flute* and the *Cor Anglais* of the harmonium; the *Flute* and the *Viola* to the *Fife* and *Clarion*. That is to say, the first two give the standard pitch, making therefore the "foundation" tone, while the second two produce sounds an octave higher than the written notes. A stop called *Sub-bass*, providing reeds of 16 ft. tone—an octave lower than the written note—to the lowest octave of the instrument is frequently met with. Take care in using it that all the notes of the bass are confined within its range.

With mechanical stops and accessories all good American organs are well supplied. Among the former are the two *Fortes* of the harmonium, but their use is restricted—the one on the right to the *Diapason* and *Melodia* stops; that on the left to the *Viola* and *Flute*. The octave coupler couples every key with the reed an octave above or below; in some instruments only above, in others only below. The *Vox Humana*, a leading feature of the instrument, controls a fan behind the soundboard; the fan, being made to revolve rapidly by the pressure of wind, meets the waves of sound, and gives to them a pleasing vibrating quality much more delicate than that produced

by the *Tremolo* stop in the harmonium. Large instruments have, in addition, a *Tremulant.* Every instrument has at least one *Knee Swell*; most instruments have two. That at the right of the player opens the swell when pressed towards the right; that at the left is usually a full organ "stop," so that by pressing it to the left as far as it will go, all the speaking stops of the instrument, except the *Voix Celeste*, are made to sound. Both swells return, when allowed, by the force of a spring.

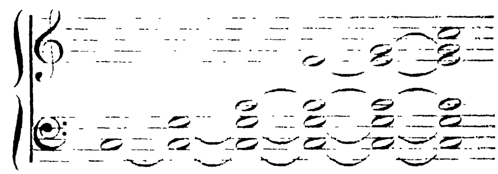
Study of Keyboard. Now, after all this preliminary, we are ready to sit down at the instrument. As we do so, let us look at the keyboard, so that we may know where to find any note as we may want it.



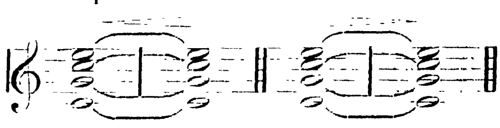
In the case of the American organ, the keyboard compass is also five octaves, but the instrument usually begins and ends with F. Instruments are, however, made with what is called the "C compass." In any case, the order of the notes is, of course, the same, the "blacks" being in groups of twos and threes alternately, with the "whites" between. If the student does not already know the names of the keys, and cannot readily pick out any given note, he had better master that point at once.

Position. All this time we have been sitting at the instrument. But something must be said about that very process. It seems a simple enough matter to get seated in front of a harmonium, but it really is not. Nothing is more important to the harmoniumist than efficient blowing; and in order to secure it—to secure control over the bellows—a good position at the instrument is essential. If the chair is too high, the blow-pedals cannot be depressed the whole way, and the player will run, besides, the risk of sliding off the seat. Again, if the chair is too low, the entire underpart of the feet will be thrown on the pedals, with the toes pointing up towards the knees. In this case you will find it difficult to exert any downward force upon the footboards, and will be gradually pushing your seat back. The chair, then, should be of a suitable height, and placed exactly in front of the middle of the keyboard. Keep the knees about an inch from the front of the case; see that only the toes and ball of the foot are placed on the pedals—the heels being left free—and think of the act of pressing as forwards rather than downwards.

The Blowing. Blowing is supposed to be quite an easy performance. It is by no means easy—that is, to blow so that a steady, continuous tone shall be produced. The student ought certainly to learn to blow first, before taking up keyboard work; and if he follows this advice he may as well learn to blow at once with the Expression stop, and thus overcome two difficulties at the same time. Let him draw, then, the Expression stop and the stops marked (1) on each side. Press down one of the digitals near the middle of the keyboard, say F, and begin blowing with the right foot only. When the pedal has reached its limit, the sound will cease. A similar result will follow the use of the left pedal. Obviously, if a continuous sound is to be produced, one pedal must be depressed while the other is rising. Here the learner will find his chief difficulty. His primary efforts will almost certainly result in a series of jerky, spasmodic sounds; and there is nothing for it but to go on practising until the sound becomes even. Get the one sound (the F) even first; then add the third above—namely, A—and be sure that you have the same good, steady tone. Add next the fourth below the original F—namely, C—and listen carefully again. Finally, strike in with the octave below the starting note; and if, with all four notes sounding together, you are able to command an even tone, you may go on to practise the following more elaborate exercise in blowing:



Here the keys are, of course, to be pressed down in the order of the notes, the previous note always being retained when the other is added. Another chord, such as this, might be taken for the practice of crescendo and diminuendo:



When these exercises can be done satisfactorily the student may assure himself that he has learnt to blow. One word of caution—beware of falling into the habit of blowing in time with the music. This is a serious, as well as a quite inexcusable, habit, for when the *tempo* is rapid the reeds will run the risk of being damaged by overblowing. Lastly in this connection, avoid all kinds of mannerisms at the keyboard. Try also to keep the body perfectly steady, without any swaying from side to side or backward and forward.

Practice. In proceeding now to direct the practical studies of the pupil, it is necessary to mention at once certain books of exercises for his use. It is, of course, assumed that no pupil starts without knowing something of the theory of music, and without being able to "read" with fair facility from the stave. More than that we do not ask. Nevertheless, the writer of these lessons must recognise the fact that many who can already play the piano want to take up the study of the harmonium or American organ.

Obviously, for such students, the course must be somewhat different from that to be laid down for the pupil who cannot play any keyboard instrument at all. The one will have to learn everything from the beginning; the other will only have to learn to blow, to practise a new style of fingering, perhaps to exercise himself a little more in reading four-part harmony, and generally to adapt himself to the peculiar conditions of the harmonium as an instrument of sustained sounds.

For the student who can already play the piano, we recommend Mr. King Hall's "The Harmonium," in Novello's series of music primers. For the student beginning from the beginning—and he will receive, of course, our chief attention—especially the student who aims at the practice and rendering of church music, there is no better book than "The Harmony Player for the Harmonium," edited by John Curwen. [See note *re* exercises on page 3860.] This work is also easily adaptable to the American organ, but if the student of that instrument can play a little already, he will probably prefer Dr. Stainer's "Tutor for the American Organ," published by Messrs. Metzler. Direct reference to all these works will be made in the course of our lessons. Let it be added that each in some way supplements the other, so that the individual student, beginner or not, will find the interest of his work greatly increased by having all three at hand.

Phrase Fingering. We will imagine, then, the beginner sitting down to a practical study of the "Harmony Player." He must first understand something of the plan of the book. It has two essential features: (1) a new art of fingering (new so far as reducing it to a system is concerned); and (2) a study of the chords more commonly met with concurrently with their production by the fingers. Of late years an improved fingering has come into use in which the player looks forward and studies the range and other peculiarities of the harmonic phrase before him, and adapts his fingering to its needs. Experience shows that this plan is much superior to the elaborate system of scale fingering once so much in vogue; a system which, as a matter of fact, is totally foreign to the character of the music generally played by the harmoniumist. "Phrase fingering," then, as it has been appropriately termed, is the first essential feature of the "Harmony Player."

The second feature touches the fringes of theory in such a way as to make practice both easier and more interesting. An intelligent knowledge of chords and chord progressions which have to be played helps the fingers in a way which those who are entirely ignorant of harmony would scarcely believe. It helps the eye, too, in reading the notation, for certain harmonic combinations are so fixed in their progressions that the player can often dispense with a visual following out of the individual parts on the staves.

Finger Exercise. We now want to get the hands a little into shape, and for that purpose select the following five-finger exercise. It looks absurdly simple, but remember that it is the "carriage" of the hand and the correct placing of the fingers upon the keys with which we are concerned just now. It will be understood that the upper line of fingering is for the right hand, the lower for the left, and that the × signifies the thumb. The left hand will, of course, be played an octave lower than written.

Let us take the right hand first. Look at the plates in the "Harmony Player," and copy the positions there shown. The thumb being placed above C, notice that all the fingers are exactly above the keys which they are to depress. When not actually in use, there is a tendency to let the thumb hang off the finger-board. It should be kept persistently to its place, about half an inch on the digitals, otherwise, when it has to be used, there will be an awkward shifting forward of the whole hand. At the moment of striking the note D, the thumb must be raised and the second finger held in readiness for the note E. Each finger will thus, in turn, come to be used when we reach G, and the exercise should be repeated again and again, until the hand has assumed its proper position and the player feels that position to be natural and easy. Be careful to get an exact "touch"—that is, to strike the notes in a prompt and decisive manner, giving to each note its due length and nothing more or less. There must be no "blurring" of one note into another; nor, on the other hand, must there be the least perceptible break between the sound of one note and another. Practise the two hands separately, and when each has gained its own facility, let them be combined. Continue this exercise till the fingers move like automatons. Then transpose it into the key of G, and repeat the process. You may also try the keys of D and F, remembering that the third note of the former will be F♯, and the fourth note of the latter B♭. There may be at first a slight difficulty in placing the fingers evenly and firmly on the black digitals; but that, too, is a thing to be mastered by persistent practice.

When you have so far exhausted this preliminary exercise, take the following five-finger exercise, practising first the right hand, then the left, and finally both hands together. Never attempt to combine the two hands until each can do its own part easily.

Strengthening the Fingers. This exercise will be found valuable for strengthening the fingers. Some hands will require to practise it more than others. It all depends upon what one's hands have had to do in the business of life. But do not get disheartened if the muscles are stiff. It is only a question of time and practice. This second exercise may, if persevered in, cause at first a little pain, but that must be borne. Do

not persist, however, in giving the hands more than they can do at any one time; rather allow them rest, and resume after a certain interval. Finger exercises are of the utmost value, and cannot be dispensed with by anyone who desires to become even a tolerable player. Merely practising the difficult passages which occur in classical compositions is not of itself sufficient; and, indeed, without a previous course of finger-training such passages will often be found impossible of execution. When you have practised the above exercise for some time in the key of C, as written, transpose it into the keys of G, D, A, E and F, still preserving the same fingering as in the example. This will assist further in the "handling" of the black keys.

Playing Separate Parts. You will have now gained a certain independent action of the hands, and will be ready to play separate parts in each. For this purpose, turn to the "Harmony Player," and look at Ex. 8. You will see that the left hand has here a part of its own, consisting of the notes C and G, used alternately. Observe that in the second, fourth, tenth, and twelfth bars, two notes are played in the left hand while one is *held* on in the right. The fingering is not marked beyond the first bar, but, of course, as the compass is only C to G (five notes), in both hands, the five fingers occupy their original places. Ex. 10 is of a similar nature in key G. The left-hand part is, in fact, exactly the same as in Ex. 8, and the right hand part has been given already in Ex. 9, which should be played over several times previously. Ex. 12 is a further development of the separate action of the hands, a peculiar feature being four notes in the left hand against one note in the right. Notice that toward the end the left hand part rises diatonically from C to G, while the right hand part also moves. This is the first example of the kind, and will require careful practice. Do not leave this exercise until you can play it with freedom without looking at your hands. Then take the exercises as they follow in order, noting that in Ex. 16 the bass again rises a fifth by diatonic progression.

Exercises 17 and 18 will require careful study in the separate parts before combination is attempted. The difficulty arises from the hands being kept at a greater distance than they have been accustomed to in the previous exercises. In Ex. 19 note that the right hand has two beats of a rest while the left plays B and A. Be careful to lift the first finger of the right hand at the moment the A has received its due portion of time. In Ex. 20 the same rest occurs in the treble part, which latter moves in a form known as sequence—that is, one phrase following the other on a definite plan at a higher or lower degree. Exercises 21 and 22 should be well practised; they are for strengthening the third finger, which, being the least used in ordinary life, and also for a physical reason, is the weakest of the fingers. Schumann invented a little machine for "bringing it right," as he vainly supposed, and many players used to have its stiffening tendon cut. B[illegible]r to get even with it by ordinary finger exercise, persistently and systematically pursued.

New Keys. We are now supposed to have carefully worked through the first step of the "Harmony Player." In this step the exercises have been *written* in only two keys—C and G, and there have never been more than two parts. The second step brings forward the keys of F, D, and B♭, and the exercises are in three parts. The first two (25 and 26) present the new difficulty in the most elementary way—that is, with a considerable use of holding notes. Notice that at the end of the first section of Ex. 25 the right hand has a rest of two beats, while the left completes the bar. Be careful to have the second finger exactly above the E which begins the moving tenor at the beginning of the second section. Ex. 26 calls for no remark, unless to warn the player against leaving the G in the tenor part at the end of the first section. Hold it down firmly while the bass plays F, E, D, C, being ready at the moment the latter comes in with the E in the treble part.

The next exercise is entirely for strengthening the fingers and adapting them to the neat execution of passages running in thirds in the same hand. It will show the learner more than anything he has yet tried how weak and stiff is the left hand compared with the right. That is only natural, of course, since in everyday life we give the left hand so little to do. To the player, however, both hands are of equal importance, and no trouble ought to be spared to make the left as supple and obedient as the right. This exercise will do something towards that end. Practise with the right hand first, being careful to press down both notes exactly at the same time. This even production of the two sounds and ultimate facility of execution at a rapid pace are the chief ends to be kept in view in working up the exercise. When the right hand begins to feel uneasy, take the left, transposing the exercise an octave lower. Presently the hands may be combined, and the exercise should be returned to daily for a considerable time. Do not over fatigue the hands; stop immediately the slightest pain begins to be felt. If the student has a piano at hand he will find material benefit by alternating this exercise between the two keyboards.

Fingering. Now look at Ex. 28. We have here a real "tune," a well-known single chant of Tallis. Glancing at the right-hand parts, you will see at once that the compass is a fourth from F♯ to B—and can therefore be covered by the four fingers. Always remember that if a passage does not extend beyond five notes, the five fingers, or as many as may be required, should be used in their natural position, one for each note. Placing, then, the fourth finger on the highest note, the first finger will fall upon F♯, and there will be no use for the thumb. From this exercise we deduce a rule which should be kept constantly in mind—*Never use the thumb on a black digital unnecessarily.* If we had placed the third finger on the B in the melody, the thumb would have been thrown on the F♯, which would have caused an

awkward shifting forward of the hand not justified by the necessity.

Ex. 29 is so simple as to call for no remark. Exercises 30 and 31 present the first examples in the key of D. In the case of the first, the second finger of the right hand is placed on D to avoid having the thumb on C♯. Be particular to restrike the D in the second bar, otherwise it will sound as being the alto note in the former bar held on. In Ex. 31 a little discomfort may at first be felt from the hands being brought so near each other, and by the left having two moving parts of its own. After good practice with the hands separately, the discomfort will vanish. Ex. 32 is in six-pulse measure, and is played properly by counting two in the bar. In consideration of this novelty, the technical side of the exercise has been kept simple. The following exercise introduces the key of B♭, in which two black digitals have again to be dealt with. Keeping in mind the rule about the unnecessary use of the thumb on a black key, the player will place the first finger on B♭, the fourth finger will take E♭, and the thumb the A. The left-hand part being only a fifth in compass, will be played by the hand in its natural position. Keep the right hand well forward on the keyboard, otherwise when you come to use the short fourth finger on the E♭ an uncomfortable forward movement of the hand will be necessitated.

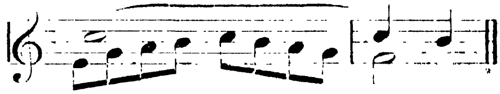
Ex. 34 has two parts in the left hand against one in the right. The compass of the latter, you will observe, is a fifth – C to G – and is covered, therefore, as before, by the fingers in original position. In the left hand see that the tenor moves neatly and exactly with the treble in the third bar. The upward progression of the left-hand part here, while the melody is stationary, has a pleasing effect, and should be artistically done. Ex. 35 will be found very valuable for further strengthening the intractable third finger of the right hand, which is held firmly on the key while the first and second fingers move. One would think it very easy to keep a finger pressed down on a certain key while the other fingers shift about, but learners often find that the finger has left its key and wandered some way out of its place. The moving part of the left hand in Ex. 35 is given to the right hand in Ex. 36 and an under part added. There is no particular difficulty here, though some hands find F♯ and C♯ in the lower part a little awkward at first. Finally, to end this step, we have the moving parts of Exercises 35 and 36 "varied," first in the left hand and then in the right.

Four-part Score. We are now face to face with a harmony of four parts, the player having been led so far, first by a course of exercises in two parts, and then by a course in three parts. This reading in parts admittedly proves a difficulty with learners, and before going further it will be well to give some advice with regard to it, and reading at sight generally.

To avoid the inconvenience which would be experienced in reading from vocal score, only two staves are used, on the upper of which are written the treble and alto parts, on the lower the tenor and bass. For the sake of distinction the stems of the notes of the higher part on both staves are turned upwards, those of the lower part downwards. When two parts come into unison—that is, have the same note—the fact is expressed by writing the note with a single head and two stems; or if the note as used in the one part is of longer duration than the note as it occurs in the other, and if the difference between the two lengths is one which cannot be expressed by the stems only, the note is written twice, once for each part, and the two notes, which are placed beside each other, are written as one. This will be seen in the second bar of the following example, where a single head with two stems would not have sufficed, as it would then have been impossible to tell whether a crotchet or a minim were intended:

Occasionally a note which is sustained in one part is required to be used a second time as a note of the other part before it has properly come to an end. In that case the key must be pressed down again where required in the second part, and this repeated note is then held for the remainder of the value of the original sustained note.

Written



Played

The correct rendering of many hymn tunes and pieces often requires an inner part to be divided between the two hands, and it will frequently be found that neither of the hands is able to reach some note in the tenor or alto part as written.

In the latter case it will do no harm to transpose the inaccessible note to the octave above or below, provided always that when so transposed it does not become higher than the melody or lower than the bass. For instance, at (*a*) of the following illustration it would be impossible to play the tenor part as written:

But when it has been raised an octave, as at (*b*), the fingers meet with no inconvenience, and the chord is then made complete. Theoretically, this method of bridging over the difficulty is incorrect, but it is the only one available.

Continued

Group 23

NATURAL HISTORY

28

ZOOLOGY

continued from page 3806

THE INTEREST IN A WORM

The Various Groups of Worms. Their Characteristics and Structure. How the Earthworm helps the Farmer. Worms and Pearls. An Industry Saved by Science

By Professor J. R. AINSWORTH DAVIS

SEVERAL groups of the lower animals are collectively known as Worms (*Vermes*), a word which has a certain convenience, but is decidedly unscientific, for most of these groups are but remotely related. The more important of them are: (1) Ringed Worms (*Annelids*); (2) Wheel-animalcules (*Rotifers*); (3) Siphon-worms (*Gephyrea*); (4) Moss polypes (*Polyzoa*); (5) Lamp-shells (*Brachiopoda*); (6) Round-worms (*Nemathelmia*); (7) Flat worms (*Platyhelmia*); (8) Nemertine Worms (*Nemertea*).

Ringed worms are elongated creatures in which the body is made up of a considerable number of rings or segments, most of which are, on the whole, much alike. There is often a well-marked head, but no distinct thorax and abdomen, as in an insect or crayfish. Two subdivisions are recognised: (*a*) Bristle-worms (*Chætopods*), and (*b*) Leeches (*Discophora*).

Worms of the Sea. Bristle-worms include a host of marine worms, together with some that live in fresh water, and also the earthworms. Their average characters are best understood by examining one of the commonest shore-worms, known as the sea centipede (*Nereis*) [**520**]. Here the segments are very clearly seen, and almost every one of them bears a pair of unjointed conical *foot-stumps*, used for crawling. The remote ancestors of the jointed-limbed animals were no doubt somewhat similar, but in the course of ages their segments have become fewer in number and more specialised, while the foot-stumps have evolved into jointed limbs.

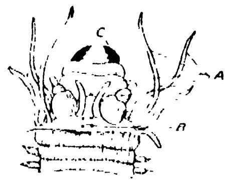
517. LUG-WORMS (Photo by Prof. B. H. Bentley)

Imbedded in the foot-stumps of the sea centipede are bundles of strong bristles, which give a hold on the underlying surface, and prevent slipping. The head region is fairly distinct [**516**], and bears a number of feelers of various kinds as well as four simple eyes. Sea centipedes and many of their allies are highly carnivorous, and seize their prey by means of a pair of horny jaws, which can be protruded at will [**516** c]. When this is done the muscular first part of the digestive tube (*pharynx*) is pushed out through the mouth.

Some of the shore-worms have become broad and flattened to enable them to live conveniently under stones and in similar cramped places, as in the so-called sea-mice [**518**]. Here it will be seen that many of the bristles are long and sharp, serving as an excellent means of defence. In one kind of sea-mouse (*Aphrodite*) they are beautifully iridescent. On the upper side of the body are a series of scales [**518**] which serve for breathing purposes.

Some of the marine bristle-worms have taken to a swimming life, and in these the foot-stumps have been broadened out into serviceable paddles. Their bodies are transparent.

A Worm that Lives in a Tube. The bristle-worms so far mentioned move actively about, but some have taken to a comparatively sluggish burrowing life, as in the case of the lug-worm (*Arenicola*) [**517**], greatly esteemed as bait, which swallows sand or mud for the sake of the nutritious matter contained therein. Foot-stumps and feelers are reduced, for they would only be in the way, but beautiful feathery gills have been developed. One of the specimens figured is abnormal, for another individual is growing out of it, like the branch of a tree.



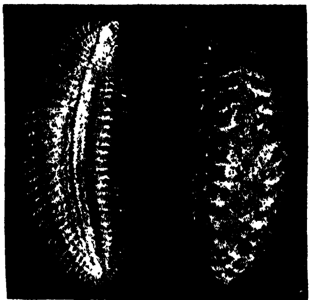
516. HEAD OF A SEA CENTIPEDE
a. Feelers *b*. Eyes *c*. Jaws

A sticky fluid oozes from the skin of a lug-worm and glues the surrounding mud or sand together into a sort of ill-defined temporary tube. Many bristle-worms, however, have taken to a purely fixed or sedentary habit, and these construct firm tubes of various kinds and shapes. They may be of horny texture, built of sand-grains and the like, or else calcareous. A worm which lives in a limy tube is figured here [**521**] extracted from its dwelling. The foot-stumps are greatly reduced, but some of the head-feelers have been converted into elegant branching plumes. These are beset with microscopic threads of living matter (*cilia*), which by their constant movement set up currents of water. The plumes themselves serve as breathing organs, and the currents they originate bring all sorts of small organisms and nutritious particles to the mouth of the worm. Below the plumes is a sort of collar, which is concerned with the making of the tube.

The sinuous calcareous homes of one of our commonest native tube-worms (*Serpula*) are often to be seen upon stones and shells [**522**]. When fully extended the single head-plume is a most beautiful object on account of its elegant shape and bright colour. On the least alarm the worm retreats into its home in the twinkling of an eye, the

opening of the tube being closed by a conical stopper, formed by modification of a head-feeler. The little spiral dwelling of another common type (*Spirorbis*) is especially abundant on brown seaweed, and here the conical front-door is hollowed out to serve as a brood-pouch, within which the eggs pass through the early stages of their development.

The Farmer's Friends. Earthworms [519] are profoundly modified in adaptation to the burrowing habit. The pointed head-end (one can scarcely speak of a head) is devoid of feelers and eyes, and the foot-stumps are only represented by rows of bristles, which can be felt if the finger be passed along the body from back to front. There are no jaws, but the muscular first part of the digestive tube (*pharynx*) acts as a kind of pump for taking in food. This consists of fragments of plants or even of animals, but mostly of earth. The worm possesses a strong gizzard, containing small stones as in a bird, and making up for the absence of jaws.

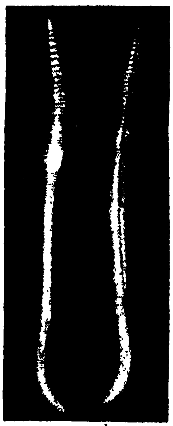


a *b*

518. SEA-MOUSE

a. Lower side
b. Upper side

As Darwin long since demonstrated, the earthworm is one of the farmer's best friends. Its burrows drain and aerate the soil; while the earth which has passed through its body is finely divided, and constantly being brought to the surface from lower levels.



a *b*

519. EARTHWORM

a. Lower side
b. Upper side

520. SEA CENTIPEDE

521. TUBE-WORM AND TUBE

Not far from the front end of an earthworm a thickening will be seen [519], often erroneously supposed to be the result of injury. From it exudes a fluid which hardens into the egg-cases.

522. TUBES OF SERPULA ON MUSSEL SHELL

(Photographs by Prof. B. H. Bentley)

Leeches. Leeches live in the sea, fresh water, or even in damp tropical forests. Their characters will be understood by examining a medicinal leech [523], which is one of the freshwater types. The flattened body is transversely divided by grooves into a number of narrow parts, several of which go to make up a segment. Foot-stumps and bristles are entirely absent, and progression is effected by means of suckers, one at each end. They effect a looping movement, but the animal can also swim by undulations of its body. This particular leech is a blood-sucking parasite. The mouth is situated in the middle of the front sucker, which serves to fix the animal to its victim. Three saw-edged jaws are then brought into play, a three-rayed cut being made, and a fluid poured out which prevents the blood from clotting. Digestion is slow, and the food is stored in a large crop, drawn out into numerous pairs of pouches. The head possesses eye-spots, but no feelers.

"Wheel-animals." The minute transparent creatures known as *wheel-animalcules* abound everywhere, provided there is a little moisture for them to swim about in. They may be kept in a dried condition for years, resuming their vitality when placed in water. Some of their leading characters may be gathered from the illustration given of a common freshwater type [525]. The body is not divided into segments, though the external membrane (*cuticle*) is transversely grooved, especially in the mobile "foot," which is provided with a pair of pincers at its end, and serves as a creeping organ.

At the front end of the body is a ciliated disc, or "wheel organ," the latter name being derived from the fact that the cilia move in regular succession, and give the impression of a rotating wheel. This is, of course, only an optical illusion. These movements enable the animal to swim, and also set up currents which bring food particles (minute organisms, etc.) to the mouth. These are ground up in a sort of gizzard, into which tooth-like structures project.

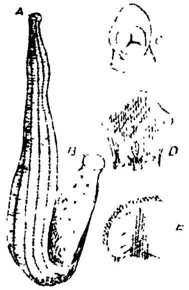
Some of the wheel-animalcules are sedentary, and construct tubular dwellings. In one remarkable case (*Melicerta*) these are made of pellets of mud, or other foreign matter, cemented together [524]. Each pellet is moulded into shape within a little cup, and there is a special cement-gland.

Siphon-worms in the Sand. Siphon-worms are distantly related to bristle-worms, but distinct segments are not to be made out, and there are no foot-stumps, though a few bristles

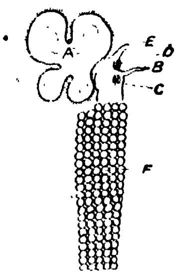
are sometimes present. The common siphon-worm, Sipunculus [527 A], burrows in sand, which it swallows, after the fashion of an earthworm. A more remarkable form is Bonellia, of which the female is figured [527 B]; the male is minute and degenerate. The animal lurks with its rounded body securely ensconced in some rock cranny, while its long forked proboscis is extended to a relatively enormous distance in search of food. This is conducted along a groove to the mouth.

Many Bodies in One. Moss-polypes are the first example we have met of *colonial* animals, in which a number of individuals (*polypes*) are aggregated together, their bodies being actually continuous. There is a horny (or sometimes calcareous) external skeleton, with a series of little cups for the reception of the polypes. The colony is formed by the budding of an original individual, and a more or less plant-like appearance is typical. A common freshwater type (*Plumatella*) is figured [528], from which it will be seen that each polype possesses a crown of feelers. These are ciliated, and serve as breathing organs, also setting up currents of water which bring food.

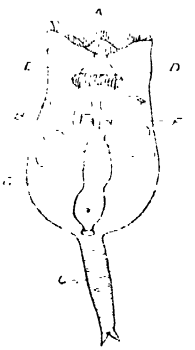
One of the best known marine kinds is the sea-mat (*Flustra*) [533], which looks very much like a flat sea weed. Upon this particular specimen tufts of another species are growing.



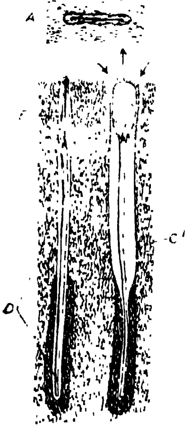
523. LEECH
a. Front, and *b*. back suckers *c*. Front sucker, with mouth *d*. The same, cut open to show the three jaws *e*. Jaw with toothed edge



524. MELICERTA
a. Ciliated disc *b*. Feeler *c*. Cement gland *d*. Ciliated cup and pellet *e*. Flap overhanging same *f*. Dwelling of pellets

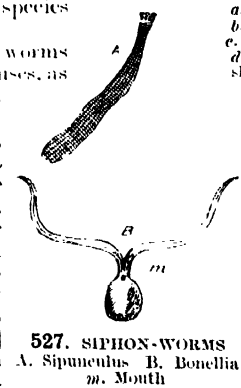


525. WHEEL-ANIMALCULE
a. Ciliated disc *b*. Feeler *c*. Foot *d*. Brain *e*. Cavity of mouth *f*. Gizzard *g*. Rest of digestive tube

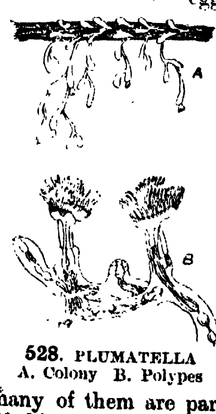


526. TONGUE-SHELL IN BURROW
a. Opening of burrow *b*. Side-view of shell *c*. Shell seen from flat side *d*. Stalk (The arrows show the direction of the water currents)

Lamp-shells. These worms are often mistaken for molluscs, as they possess a bivalve shell, the valves of which, however, are *upper* and *lower*, not right and left, as in a mussel or cockle. In the tongue-shell (*Lingula*) [526], the shell is horny, and the animal lives in a burrow in the sand. Between the two halves of the shell a fleshy stalk passes out, and this can be contracted [526 C] so as to draw the animal down out of danger. Projecting from the sides of the mouth are two ciliated fringed "arms," which play the same part as the crown of feelers in a moss-polype. In lamp-shells [529-530], the valves are transparent, and calcareous. The lower one is much larger than the other, and is pierced by a hole through which the short stalk projects. This serves to fix the lamp-shell to some firm object.



527. SIPHON-WORMS
A. Sipunculus B. Bonellia *m*. Mouth



528. PLUMATELLA
A. Colony B. Polypes

Round-worms: A Danger in Food. These are unsegmented worms of cylindrical shape, pointed at either end. Most of them are internal parasites, which give rise to serious or even fatal disease. An example of one of the larger forms (*Ascaris*) is figured [532], the sharply bent tail showing it to be a male specimen. Well-known species of the genus infest the horse and human beings. Another obnoxious round-worm (*Dochmius*) attacks the lining of the small intestine in man, and causes "miner's anaemia."

The female of the Guinea-worm (*Filaria medinensis*) lives under the human skin in tropical Africa, setting up abscesses. Its slender body is two feet in length or even more. A minute related species swarms in the blood of human beings in tropical regions, but is only to be found there at night. The round-worm, however, which is most dangerous to man is a form known as *Trichina*, which is under one-twelfth of an inch long. It infests the rat, and if this should be eaten by the pig, as it often is, the young worms bore into the walls of the stomach, and are carried in the blood to the muscles, where they pass into a quiescent or encysted condition. Should a human being eat insufficiently-cooked pork containing the young worms, they become mature in the stomach, producing countless eggs (as many as 1,000 per female), the embryos hatched from which make their way into the muscles, and become encysted. Serious illness, and not infrequently death, result from the disturbance thus set up, for though the parasites are very small, as many as 40,000,000 may be present in the same victim.

Flat-worms. These are unsegmented forms in which the body is generally flattened from above downwards. Very many of them are parasites with a complicated life-history. There are three groups of these

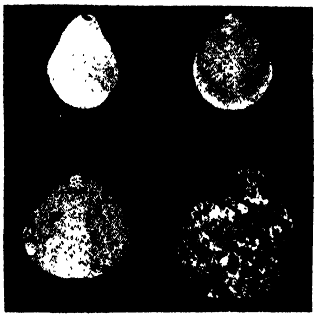
creatures, (1) Planarian Worms (*Turbellaria*), (2) Flukes (*Trematoda*), (3) Tapeworms (*Cestoda*). Planarian worms abound both in salt and fresh water, and some of them are even found upon damp earth. Their skin is soft, and closely beset with cilia, by means of which they are able to glide along in a characteristic way. Planarians are highly carnivorous in habit and possess a long muscular pharynx, which can be protruded from the mouth in search of prey [535].

A Sheep Parasite. The *fluke* group is closely allied to the last one, but the animals included in it have become greatly specialised in relation to the parasitic habit. The covering of cilia has been lost, while suckers and other organs of attachment have been developed.

We may conveniently take as an example the liver fluke (*Distoma hepaticum*), the cause of the disease known as "liver-rot" in sheep. [See AGRICULTURE, page 2625.]

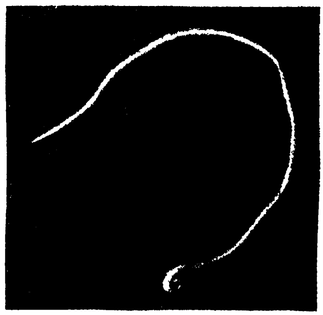
The adult parasite, which attacks the liver of the sheep, is leaf-shaped [537], and an inch, or rather more, in length. The mouth is in the middle of a sucker, and situated on the end of a conical projection. A second sucker is present on the under-side of the body, far forward. The food consists of blood, and disintegrated liver-substance, taken in by the action of a pharynx that serves as a suction pump, and passed on into the numerous branches of the forked intestine. Very large numbers of eggs are produced, as will be realised from the fact that the gall bladder of a sheep infested by about 200 flukes contained something like 7,400,000. Parasites of all kinds are notoriously fertile, especially when their life-history is complex. The chances of survival in a given case are so small that if it were not so they would soon become extinct.

529. LAMP SHELLS

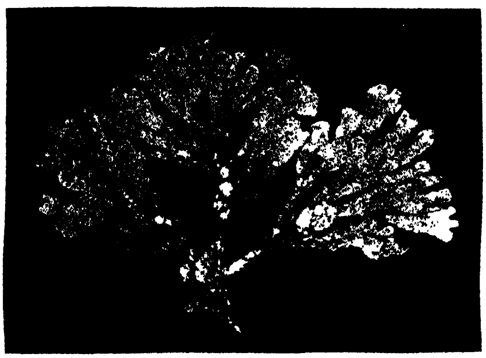


530. LAMP SHELLS
a. Upper valve *b*. Under valve

531. TAPEWORM



532. MALE ROUND-WORM
(Sex is shown by the curly tail)



533. SEA-MAT
(Photographs by Prof. B. H. Bentley)

The eggs of the fluke ultimately pass out of the body of the sheep, and if this take place on damp ground in the vicinity of water, they have a chance of developing further. Low-lying pastures liable to be flooded offer particularly favourable conditions. A minute ciliated embryo hatches out from the eggs [537 B] and swims actively about in search of a small species of water snail (*Limnæus truncatulus*), soon perishing if unsuccessful.

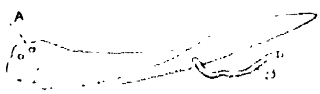
The ciliated embryo bores into the lung chamber of the snail and becomes an irregular germ-bag [537 D]. Within this the next stage or *redia* is developed, which makes its way to the snail's liver and feeds upon it. During the summer several generations of rediæ arise, one within the other, by a process of internal budding. Later on in the season the next stage (*cercaria*) is similarly formed within the bodies of the last generation of rediæ. It resembles a minute tadpole in shape [537 F], and makes its way out of the snail, swimming to the stem of some water-plant, losing its tail, and passing into a quiescent or encysted stage, in which it is surrounded by a limy covering. If a sheep crops some herbage to which the cysts are attached, their limy coats will dissolve in the stomach, and the young flukes thus liberated pass on into the intestine and make their way up the bile duct to the liver.

Tapeworms. All the tapeworms are internal parasites, and the characters of some of the more simple among them show that these creatures have descended from fluke-like ancestors by still further modification. Digestive organs,

in the ordinary sense, are entirely absent, for these creatures live surrounded by nutritious food in the liquid form, consisting either of the digested food or the blood, etc., of their hosts. This is absorbed through the soft covering of the body.

One of the best-known members of the group is the common tapeworm (*Tænia solium*), which lives, when adult, in the intestine of human beings [531 and 536]. At the front end is a minute "head" which holds on by hooks and suckers to the lining of the intestine. Behind this are very numerous flattened joints (*proglottids*), of which the ripest are those furthest from the head. Each joint gives rise to a large number of eggs, and since new joints are constantly being formed during the life of the worm, there is little likelihood of the parasite becoming extinct.

534. NEMERTINE WORM



535. PLANARIAN WORM

a. Eyes *b.* Extended pharynx

536. TAPEWORM

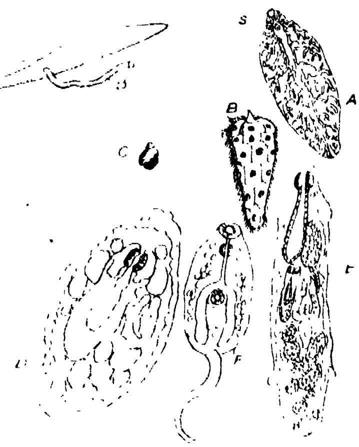
a. Head, with hooks and suckers *b.* Six-hooked embryo *c.* Young bladder-worm (section) *d.* Full grown bladder-worm

The ripe tapeworm joints pass out of the body of the host, and if any of their eggs chance to be swallowed by a suitable warm-blooded quadruped, especially the pig, they develop further [536]. A minute spherical embryo hatches out, and by means of six little hooks it possesses bores into the blood-vessels and is carried to the muscles. Here it passes into the quiescent bladder-worm (*cysticercus*) stage, in which it may remain indefinitely, for no further development can take place in the body of the pig. Pork infested by bladder-worms is said to be "measly," for the encysted parasites give it a spotty appearance.

The bladder-worm is a hollow sphere, the wall of which is pushed in at one spot. This in-pushing is gradually converted into a tapeworm head, hollow, and outside in. Should a human being eat some measly pork which has been insufficiently cooked, the tapeworm head of the bladder-worm turns inside out, and becomes solid, while the bladder itself is absorbed. The head attaches itself to the lining of the small intestine, the chain of joints develops, and the adult stage is reached.

How Science Saved a Pearl Industry. The finest "orient" pearls of Ceylon are merely the tombs of dead tapeworm embryos. In this case there are *three* hosts, and their life-history is as follows:

1. Ciliated embryos which hatch out from the eggs enter the bodies of pearl oysters, and pass into the bladder-worm stage. Some of these die and get surrounded by layers of limy matter; hence pearls.
2. The file-fish (*Ballistes*) feeds upon the pearl oysters, and some of the bladder-worms taken in develop a stage further.
3. A large ray (*Trygon*) preys upon the file-fishes, and within its intestine the tapeworm attains its full development. Tapeworm eggs pass out of the body of the ray, and the embryos which hatch from these attack the pearl oyster.



537. LIVER FLUKE

a. Adult fluke with branched intestine and two suckers (*s*) *b.* Ciliated embryo *c.* Water snail *d.* Germ bag *e.* Redia *f.* Cercaria

The pearl tapeworm affords a good example of the value of scientific research to industry. A few years ago the Ceylon pearl fisheries became greatly depreciated in value, and to discover the reason became an urgent matter. First came the so-called "practical" man, who, reasoning by the "light of Nature," suggested that file-fishes should be ruthlessly exterminated, since they devour pearl oysters. Fortunately the aid of scientific investigation was next invoked, and the life-history given above was made out, proving conclusively that extermination of the file-fish would do away with the formation of orient pearls altogether.

A Rare Sight by the Sea. Nemertine worms, unsegmented and usually cylindrical, are a numerous marine race, though practically unknown to other than professional zoologists. Some of them are much elongated [534], and may be found coiled up in odd corners between tide-marks. One of our commonest British species is jet black in colour and several yards long. Helpless though these creatures appear, they are eminently carnivorous, and devour tube-worms. At the front end of the body, immediately above the mouth, which is on the under-side, a small hole may be seen. Through this a long tubular proboscis can be shot out, and this is the means by which prey is secured. In some nemertines its tip is armed with sharp stylets, at the bases of which poison-glands open. Nemertine worms have a considerable theoretical interest, because in some respects their structure foreshadows the peculiarities of backboned animals, which possibly have taken origin from creatures of the kind.

Continued

TESTS AND TESTING

Inspection. Testing Machines. Test Bars. Castings. Impact Tests. Hydraulic Tests. Machine Tools. Cranes. Engines. Electrical Machinery. Testing Rooms

WORKSHOP PRACTICE
continued from page 3889

By JOSEPH G. HORNER

TESTING, as done in the engineers' shops, is the work of the firm in the first place, preliminary to that of inspectors, who are appointed by the purchasers. Hence there are often two separate testings made, one for the satisfaction of the firm before calling in the inspector, the other which is done by the latter. Often, however, in big contracts, the inspector remains on the premises, observing the work in its progress as well as noting the quality of the materials being used.

Inspectors. An inspector, to be fully qualified, should possess an intimate practical knowledge of materials and operations, such as can be gathered only during a considerable period spent in the shops. With this must be combined a good training on the technical side. Too often inspectors fail in the first, to the intense irritation of manufacturing engineers. Work is condemned without just reason because the inspector is not qualified to judge between the essential and the non-essential. The strict letter of a specification is insisted on, to the condemnation of really excellent work. The same kind of mistake is often made on the part of consulting engineers, who draw up specifications with unnecessary increase in cost and without increased efficiency.

The character of the tests made vary with every class of mechanism. Generally they commence with the rough castings, or forgings, or other articles. That section which relates to the taking of test pieces, having been treated in Materials, need not be repeated. But the following points lie outside the mere laboratory work.

Test Pieces. Test pieces must be taken from the actual material used in given iron or steel castings, in steel plates, or sections, or forgings. If in castings, they must be run on the castings, to be cut off in the presence of the inspector, or else poured from the same ladle in the presence of the inspector, and stamped by him. Steel plates and angles must have sufficient additional length or width to permit of one or more test pieces being shorn, or sawn off, one or more from a batch of the same quality, also in the presence of the inspector, and stamped.

Testing Machine. The test bars for castings are usually 3 ft. 5 in. long, by 1 in. wide, by 2 in. deep. They are laid on supports 3 ft. apart, with the 2 in. dimension depthwise, and loaded until fracture occurs. This takes place at from 28 cwt. to 36 cwt., with a deflection of three-eighths of an inch. Plenty of machines are used in foundries in which actual loads are applied directly to a sling hung from the bar. But the lever machine is far neater and better. Fig. 352 illustrates one of the best designs, by Messrs. W. & T. Avery, Ltd., of Birmingham. It has a capacity of 40 cwt. It takes cast-iron bars of 2 in. by 1 in. section, or less, and up to 36 in. between the supports, or dogs, CC. The bed-plate D is of cast iron, machined, and the dogs have hardened edges where they come into contact with the specimen. They are adjustable to suit different lengths of bars, and the base-plate is graduated so that the specimens may be accurately located for spans of 12 in., 24 in., or 36 in. between supports. A cast-iron standard, E, is machined and bolted to the bed-plate, and is fitted with hardened steel bearing-blocks, upon which the fulcrum knife-edge of the steelyard F rests. Brass caps are fitted over the main fulcrum knife-edge to protect it from dust. The steelyard is made of wrought iron, machined and polished bright, and fitted with hardened steel knife-edges, and graduated up to the full capacity of the machine, thus dispensing entirely with the use of loose weights.

The Testing Machine at Work. The steelyard is provided with a sliding poise, G, by means of which it is kept in equilibrium, and the strain indicated. To ensure the strain being steadily and evenly applied, and the most accurate results attained, a small hand-wheel, H, is fitted to the poise for propelling the latter. A buffer spring is fitted in the carrier J to minimise the shock on the steelyard due to the breaking of the specimen. The hand wheel is keyed to a spindle passing through the poise, and to this is also fastened a hardened steel roller having a milled edge. The rotation of the hand-wheel causes the milled roller to grip the top face of the steelyard, thus giving motion to the poise. To facilitate the movement of the latter, a trailing roller is provided with a turned edge; this also runs upon the top face of the steelyard, and relieves the milled roller of the greater part of the weight of the poise. A graduated scale and pointer is attached to the machine for ascertaining the deflection of the specimens being tested. The strain is applied by actuating a hand-wheel, K, with a screw working in a stirrup, L. The point of the screw is hardened, and bears in a hardened steel bearing-block on the edge of the steelyard.

Limitations of the Test Bar. But this method of test in any hands but that of an experienced man is apt to be misleading. It would not do to apply the results rigidly to castings made from the same bars. But it does, nevertheless, indicate the quality of the iron in a valuable way, and provided the castings are also tested to detect any unsoundness or faulty portion, the test bar will not be misleading. But

if a casting is accepted as sound and strong only because the test bar is sound and strong, trouble will in many cases follow. By the aspect of the fractured surfaces—their dull or lustrous appearance—the experienced inspector is able to form an approximate estimate of the character of the iron, whether poor or good, hard or soft. Uniformity must never be looked for either in test bars or in castings run from the same ladle of metal. Variations of 10 or 20 per cent. occur in bars, and twice as much in castings of variable sections. This is one reason why a large margin of safety must be allowed. Hence test bars alone are not relied on in a rigid system of inspection, but a small percentage of castings is broken. These are taken at random, and are therefore reliable samples of the whole.

There is one aspect of the test bar that has only been taken account of in late years—namely, shrinkage. Here we touch the fringe of a wide subject, known to foundrymen as *Keep's tests*. Though ultimately based on the chemistry of the iron—namely, on the proportion of silicon present in relation to other elements, carbon chiefly—and to the mass of a casting, the shrinkage of the bar is used as a test to reveal the physical characteristics of the metal. Where Mr. Keep's testing appliances are installed, very precise tests can be made with little risk of error in judgment.

Castings. The test pieces from a casting or a steel plate may fulfil the terms of the specification as to strength and ductility, etc; but that does not guarantee a sound casting or plate, which must be the object of a careful inspection.

Castings offer by far the greater difficulty, plates being generally homogeneous and reliable. Castings are often not homogeneous, besides which they are subject to faults developed in pouring and cooling, faults in the mould, or due to bad proportioning. Many of these are hidden, though their existence may be suspected by an experienced man. They may often reduce the strength of a casting by as much as 50 per cent., so that the test piece alone becomes illusive.

Faults. The worst faults in castings are draws, blowholes, and general sponginess. A rough skin should not condemn a sound casting, but the faults just named should, if they exist in vital parts, condemn a smooth casting. By vital parts are meant those which are subject to severe stresses of a tensile or cross bending character. Faults may occur in parts which are subject to little stress, or to one of a purely crushing character. They may occur in the neutral axis of a body or in the centres of masses surrounded with metal far in excess of that required for mere strength, as in some portions of machine framings, or bed-plates. Hence the inspector must judiciously make a distinction between the vital and the non-essential.

Draws. Draws, or open spaces, are as often as not invisible from without. If due to the shrinking of metal away from central portions, there is no indication of their presence. But wherever thin and thick portions tie one another, draws may be suspected. Hammer taps will then indicate a tense condition. Draws need not occur in a properly designed casting. But the moulder can do much to avoid the errors of the draughtsman by judicious local cooling off, or, in steel, by filling in fillets in weak places.

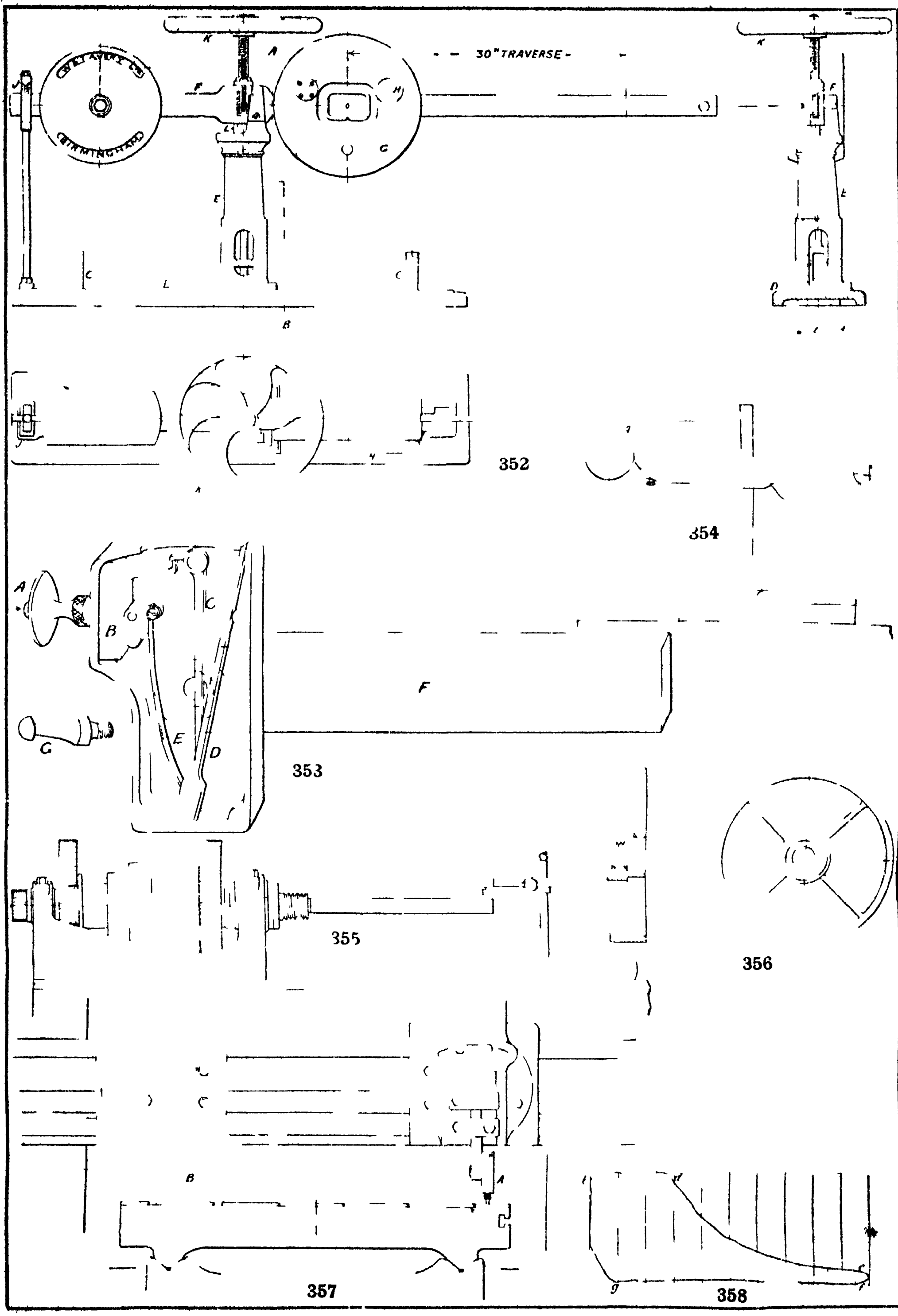
Blowholes. Blowholes and general sponginess are due to insufficiency of vents. A clean surface may conceal sponginess. The hammer test may detect it, or small holes on the upper surface may indicate the presence of extensive blowholes which may be probed by a wire. Blowholes are most liable to occur on the upper faces of castings.

Scabs. Scabs are visible on the outside and if the fettler has trimmed them off, the smooth surface indicates what he has done. Then holes are present somewhere in the casting, because the scab is simply metal taking the place of sand that has been flaked off and washed away at the time of pouring, and lies somewhere in the mould. Such a casting, if subjected to much stress, must be regarded with suspicion, and may have to be condemned.

Plates, sheets, and angles are liable to pitting, and to seams or laminations, but far less so in steel than wrought iron. Steel is practically homogeneous; poor iron is not. But if sponginess is present in a steel ingot, it will show in the rolled plates. These faults can be detected only by ocular examination, and by hammer blows in the case of laminations, which, if present, do not emit a clear, ringing sound like a solid plate does.

Impact Tests. These are used for railway rails, tyres, and axles, because the stresses which these have to sustain are of the nature of shocks or hammer blows. Tensile tests are usually taken also, but the rails, tyres, or axles must pass the drop tests before they are accepted. These vary in different countries. In England engine axles are tested by the falling of a 1-ton weight through a distance of from 25 ft. to 30 ft. The number of blows varies, ranging from five to sixteen. The axles are laid in bearings 3 ft. 6 in. apart, and are reversed after each blow, or each alternate blow, so that the result is a number of bendings, ranging from 2½ in. to 3 in., and straightenings, which the axle must endure without sign of crack or fracture. Then, having withstood these, the axle is broken, and specimens cut from it for tensile and bending tests in a machine. Rails are tested in a similarly severe manner, with considerable variations in different countries. Tyres are also subjected to a drop test, being stood edgewise, and receiving successive blows from a 1-ton weight dropped from an increasing range of heights, extending from 10 ft. to 30 ft., until it is bent through a distance of one-sixth or one-eighth of its external diameter without cracking.

Finished Mechanisms. These, speaking generally, are tested by the agencies by which they are stressed in practice, as steam, water, imposed loads, etc. The tests may have for their object the strength of the mechanisms, or their rigidity, or stability, or



TESTING APPLIANCES

352. Transverse testing machine **353.** Test indicator **354.** Indicator testing running of spindle **355.** Testing alignment of lathe spindle **356.** Special face-plate for testing cross slide of lathe **357.** Testing parallelism of cross rail with planer table **358.** Indicator diagram

the tightness of joints and seams. In another class of test, speeds, discharge, capacity, power, etc., are ascertained.

Steam-pressure Tests. Testing by steam pressure to be sure of the strength of a vessel is practised to but a limited extent, and then, as a rule, following hydraulic tests. Even in steam boilers, with the exception of the locomotive, it is not generally practised. Many hold that it is of no value, while it is certainly risky to test a boiler at much higher pressure than that at which it has to be worked. The hydraulic test fulfils the required conditions equally well, and involves no risk whatever. On the other hand, testing by steam is done under working conditions of expansion due to heat, and these will often find out weak and leaky seams that a higher hydraulic pressure had failed to detect.

The Hydraulic Test. This is by far the most valuable and most extensively employed. It can be regulated within any range with absolute precision, from a few pounds to two thousand pounds or more to the square inch. It tests the strength of pipes in iron, steel, copper, and copper alloys; the tightness of welded and riveted joints, of caulked, of flanged, and other joints. If a joint fails, there is just a fizz of escaping water, or a mere *weeping* only, and the pressure is relieved at once, and therefore there is no danger as there is with the highly elastic steam. Pressure water finds out spongy metal, and weeps through it, hence cast pipes are tested thus. It will find its way through bad welds, through boiler seams imperfectly riveted and caulked. It will force its way between the leathers and rams of hydraulic cylinders if the leather and the fitting are poor. The test pressure pump is used, fitted with a gauge which indicates the rising pressure accurately.

Deflection. The amount of deflection of a beam or structure under a dead or a live load is very important, and specifications are generally stringent on this point. The maximum load on a structure must not stress it beyond the elastic limit, and the structure must therefore possess sufficient rigidity or resistance to enable it to return to its original form on being relieved from its maximum load. This original form need not be that at which it leaves the manufacturer, but that which it takes after it has acquired a *permanent set*. But specifications as to amounts of deflection permissible guard these contingencies, and the inspectors have to see that they are fulfilled. Sometimes firms have had to substitute new girders for others that would not stand the deflection test.

Alignment. This signifies the centres or axes of shafts, spindles, bearings, etc., being in one plane, or in line. It is most important in lengths of shafting, in machine tools, and engine rods. It is tested in some cases by the same methods as those used in erection, namely, by straining lines, and by parallel straightedges and spirit levels, or by plumb lines. But for fine machine construction this would not be accurate enough. Centres may be brought together, but that is not sufficient in some cases. Fine alignment is checked with an indicator, the point of which is brought to the centres, or axes, and any departure from accuracy is magnified at the other end by a pointer moving over an index. There is also a practical testing commonly done in lathes, which will be noted immediately. Alignment in moving pistons and rods, and crossheads, or slippers in their bores, glands, and guides is often tested after erection by moving them along, and judging of the fitting by the ease or stiffness with which they work.

Stability. This is one of the essentials in structures which are subjected to stresses tending to disturb their equilibrium. It has its applications in locomotives and rolling stock, and in balanced jib cranes of all kinds, but specially in the travelling types. The higher the centre of gravity, the smaller, other conditions being equal, is the stability. Hence, weight is, when possible, massed low down to lower the centre of gravity; and the base, whether wheel base, or foundation plates, or beds, is made as broad as practicable.

Horse-power. This is estimated as the number of pounds, 33,000, lifted one foot high per minute. It is ascertained by calculation, or by brake, or other dynamometer, or by the indicator.

Speeds. These are reckoned by observation if slow and not extended over a long time, as the speeds of shafts, revolutions of some engines, and machine tools. But under opposite conditions a revolution or speed-counter is used, which records automatically the number of revolutions.

Modulus of a Machine. In plain words this means the efficiency of a machine, or the relation or percentage of the work which it is capable of doing to that which is put into it. It is always a fractional part, since no machine can possibly give out all the energy it receives, unless it were absolutely frictionless. Calculations based on theoretical figures are of little value here because there are so many sources of loss which go to make up the total. The only practicable and reliable way is to test the machine as a whole, and when the work which is applied to it and absorbed by it is known, then the percentage between that and the work done represents the modulus, or efficiency. But this holds true only under identical conditions. The efficiency will not be the same under different loads because, in general, frictional resistances remain constant under greater or lesser loads, due to the surfaces in contact. Thus a planing machine absorbs nearly as much power while running idly as when cutting metal, due to the inertia of the heavy table. The power of an engine varies directly as the steam pressure and velocity, so that it is easy to double the power of a given engine without affecting the friction much. In hydraulic rams and pumps, and in machinery running at very high speeds, friction and ill-balanced parts complicate matters, but in average machines the remarks just made hold good. If therefore, as the result of test,

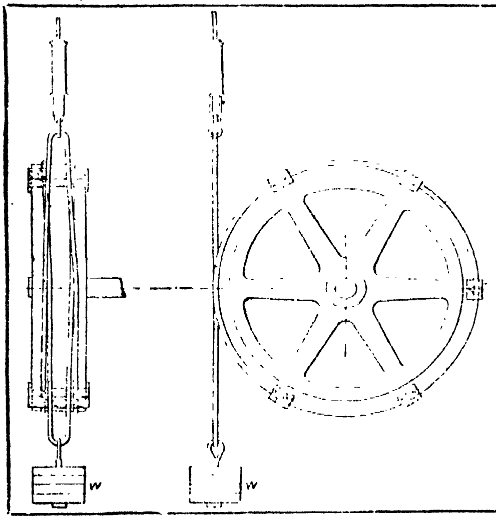
the modulus of a machine working under given conditions is known, that of machines of different powers can be ascertained. The gross horse-power, or foot-pounds of work absorbed are multiplied by the modulus.

Testing Machine Tools. Machine tools are subjected to tests for accuracy and for capability to perform the work demanded. The latter is chiefly a question of driving power and strength of parts, combined with close fitting, to prevent slackness, except as regards the capacity for speed, which is governed in many cases, such as in automatic screw machines, by the skilful setting of cams, etc.

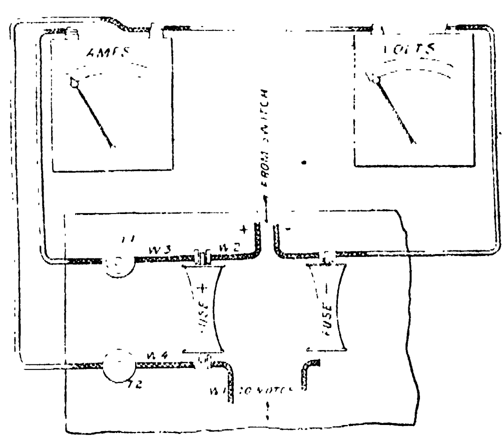
Machine tools are used for the production of true surfaces on work, so that questions of alignment, parallelism, and squareness of spindles and slides in relation to each other are of paramount importance, whereas in an engine, pump, etc., so long as the parts work correctly and freely, it may be passed. But a machine tool may look and operate apparently to perfection, and yet be very inaccurate in its product. In good work it is usual to test relations after the fitter and erector have done their part, and see that the permissible limits of error are not exceeded, absolute accuracy of course not being attempted. The principal forms of tests relate to:

Lathes: Alignment of the headstock and poppet axes in regard to each other and to the bed, and squareness of the rest setting, so that turning, boring, and facing shall be effected parallel, and at right angles. *Planers*: Square relation of the uprights with the tables, and parallelism of the cross rail therewith. *Shapers*: Parallelism, and squareness of the ram movement in regard to the table. *Slotters*: Perpendicular movement of the ram to the table slides, including rectangular relation of the latter in regard to each other. *Millers*: Parallelism, and squareness of the spindle in relation to the table, and truth to the latter at right angles. *Drillers* and *borers*: Perpendicular relations, and parallelism of the spindle to the table or base. *Grinders*: Alignment of spindles to beds and tables, and squareness of cross movements.

Indicators. In those machines which have rotating spindles care has to be observed that they run truly, since a very slight amount of eccentricity will spoil results, especially in lathes, milling machines and grinders, while in drilling machines the "running out" of the drill causes much annoyance and risk of untrue work. In testing such spindles, a plug, ground truly and parallel, is inserted in the centre of the mandrel hole, and the spindle is revolved. An indicator is then made use of [353], a delicate instrument comprising a system of levers which magnify the movement of a stud or feeler, A, screwed into a pivoted block, B, which moves levers C and D, the last having its end travelling across graduations on the top of the casing. The levers C and D enormously magnify the movement, so that a motion of 1,000th in. of A shows as $\frac{1}{8}$th or $\frac{1}{16}$th in. on the end of D, according whether A is screwed into an upper or a lower hole in the block B. The spring E tends to keep the parts at normal positions. The shank F is for holding the instrument in place on machines, etc., the case being pivoted so that if too much movement is applied to the feeler the levers will not be damaged but the case will tilt back. A cover is screwed to the face by the holes seen, to protect the parts. The feeler G is for testing inside holes, while other forms are made for special work.



359. DYNAMOMETER



360. ARRANGEMENT FOR ELECTRICAL TESTING

Lathe Testing. Another kind of indicator [354] comprises a pointer which is so pivoted that any movement is greatly magnified, and indicated on a divided scale. If the plug, therefore, held in the lathe or other spindle should happen to run eccentrically, the needle B of the indicator will move in sympathy, while if no inaccuracy is present the needle remains stationary. All circular revolving parts may

therefore be tested in a more delicate and easy manner than by setting the machine to work. The alignment of the spindle with the bed is tested by using a longer plug [355] and guiding the indicator base along the vees, or ways of the bed, so that any want of parallelism between plug and bed is shown. Or a short mandrel may be placed in the spindle and a couple of collars turned up on each end with a light cut travelling the rest from one to the other; these should be identical in diameter when measured by a micrometer caliper. If one is larger, then the spindle is not in aligament with the bed. The indicator in 355 is a type where the pressure on the feeler moves a needle over a circular dial in the case.

The alignment of the loose poppet is secured if an indicator held in the rest bears equally when brought to either end of a ground parallel shaft mounted between the heads. The barrel itself may also be tested by the use of a plug inserted as in the case of the headstock.

Squareness of movement of the cross slide is shown by its capacity for facing a plate flat, since if the tool leaves the surface either concave or convex, this shows that the slide does not move at right angles to the spindle. A neat method of testing is to make a special plate [356], projecting out into two rings, one at the periphery, the other encircling the screw hole. After a cut right over these rings, a straightedge laid against it should grip pieces of tissue paper between the four narrow faces, *a*, *a*, *a*, *a*. Should the facing be concave or convex, the paper will fall from the inner or the outer rings respectively.

Linear motions of slides or rams in relation to tables and beds are tested with the indicator. By clamping the stem in the tool-box of a planer, for instance, and moving the box along the cross rail, the want of parallelism of the latter to the table is detected by the needle moving if the feeler presses the table harder on one side than the other [357, A and B]. Shapers may be tested by holding the indicator in the tool box and moving the ram to and fro, and the table also transversely, any divergencies in the extreme positions showing themselves. Parallelism of spindles to tables, as in milling, drilling, and boring machines is found by sliding the indicator along either the spindle or the table, the feeler making contact evenly all along unless the spindle lies out of parallel. These examples are sufficient to show how testing is carried out, being representative of the work in general. It may be noted that in many shops the inspector has to furnish a report of the test, giving as far as possible the amounts of inaccuracy present in the main parts. As mentioned previously, these inaccuracies must not exceed a predetermined amount, which varies, of course, as the machines are of common or of high class construction.

Crane Testing. Cranes are tested for stability, lifting capacity, and power consumption. The stability of a jib crane is measured in reference to the gauge of rails upon which it runs or to the length of support afforded by the blocking girders. In the case of a fixed crane, the foundation is proved by the test load. The test load imposed is usually in excess of the working load; for ordinary cranes, 20 per cent. overload is usual, but this rises to 50 per cent., and even 100 per cent., for special cranes. The load is applied gradually, half or two-thirds loads being successively lifted, and the behaviour of the crane carefully noted. A common device is to apply a long lever under the crane tail from time to time during the test, to ascertain what margin of safety exists.

Cranes are also tried for backward stability with the load off and the tail at right angles to the track. Many railway breakdown cranes are not stable in this position, except when the blocking-up girders are in use; such cranes are usually fitted with movable ballast weights. The overload test also proves the capacity of the crane to perform its various movements properly.

With overhead travellers and goliaths, the test load is also used to ascertain the deflection of the main beams; this may vary from $\frac{3}{8}$ in. to $1\frac{1}{4}$ in., according to span and construction of girder. This deflection is apart from permanent set, which must be noted by measuring the level of the beam before any load is imposed and measuring again after the test load has been lifted and set down. Permanent set depends largely on the workmanship of the joints, and may be equal to the deflection in amount.

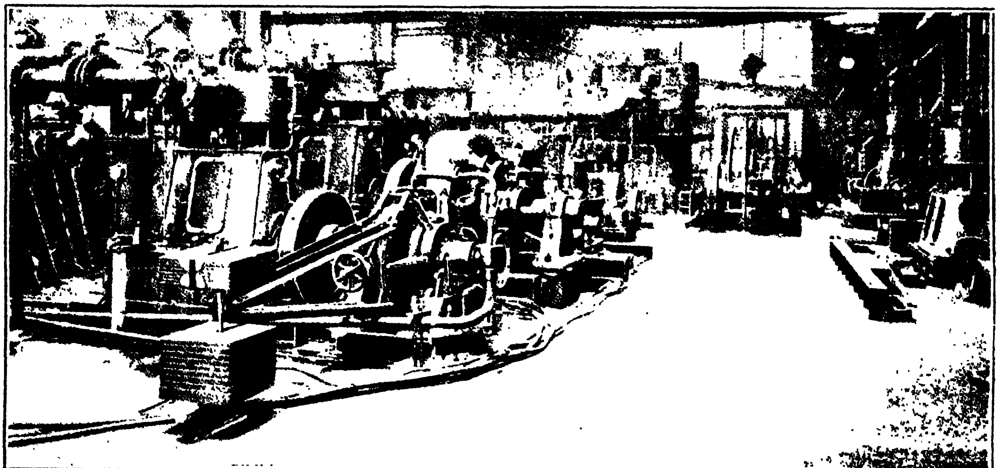
Speeds are measured by noting the time taken to carry out a certain operation and then reducing it to feet per minute. Locomotive cranes are tested for travelling speed and for shunting power, also for steaming power. A locomotive crane boiler should maintain steam at or about the working pressure easily throughout the period of testing. Coal and water consumption is easily noted during a test, or for a complete day's work. Electric cranes are also tested for current used over given periods, and the results are reduced to tons per kilowatt hour, or, alternatively, to cost of current per ton handled.

Cranes are subjected to trials for efficiency in a similar manner to that to be described immediately for electrical machinery. Crane-building establishments record all their tests, and use the comparative results as a guidance in the design and manufacture of subsequent cranes. They are thus eminently qualified to act as advisers when specifications are being framed for prospective lifting appliances.

Engine Testing. Steam engines are tested to ascertain their indicated and brake horse-power, also for steam consumption and general efficiency. The indicated horse-power of an engine, or I.H.P., as it is termed, is obtained by means of an indicator, which records the actual steam pressure in the cylinder at the various periods of the stroke of the piston. The indicator is attached to the cylinder by small steam-pipes, and is driven by the engine crosshead by means of levers. It produces a diagram as in 358. The area of the boot-shaped figure represents the work done by the piston; its length is the stroke of the piston, whilst vertical dimensions give the varying pressure as the

steam is cut off, and then expands. The mean height is the average pressure, and this, multiplied by the piston area in square inches and by the piston speed in feet per minute and divided by 33,000, gives the indicated horse-power.

In the diagram [358] *a* represents the point at which steam is admitted to the cylinder. From *a* to *b* the steam rises, making, in a good diagram, a vertical line. The paper on the indicator cylinder rotating, the line *b c* should be straight. At *c* the steam begins to be cut off, and the line drops to *d*, the point at which it is fully cut off. From *d* to *e* the steam is working expansively. At *e* the exhaust is opened and remains open from *f* to *g*. At *g* the exhaust is closed, and cushioning takes place to *a*, where steam is again admitted for the next cycle. This is the diagram for a high-pressure engine, in which *f g* is the atmospheric line. In a condensing engine, *f g* would represent the vacuum line, and the atmospheric line would be higher up. The 10 vertical full lines are ordinates.



361. STEAM ENGINE TESTING SHOP

To get the total area, the spaces between these are divided midway, as indicated by the dotted lines, their lengths are measured, and added, and the sum divided by 10. The result is the mean pressure on the piston per square inch. Thus:

$$\frac{\text{Area of piston} \times \text{mean pressure} \times \text{speed of piston in feet}}{33{,}000} = \text{H.P.}$$

The indicator diagram is an open book, which shows as clearly what is going on within the cylinder as the stethoscope reveals the condition of the lungs. Abnormal cards show whether the exhaust opens too soon or too late, or closes too soon or too late, and much more.

The brake horse-power, or B.H.P. is measured with a dynamometer, as in **359**; this particular form is known as a rope brake, and is applied to the flywheel of the engine. The weight W is adjusted to suit the load, and the B.H.P. is found by multiplying the weight by the circumference of the rope circle, and by the speed of the wheel in revolutions per minute, and dividing by 33,000. The difference between the I.H.P. and B.H.P. represents the friction losses in the engine, the relation

$$\frac{\text{B.H.P.} \times 100}{\text{I.H.P.}}$$

gives the efficiency per cent., which may vary from 75 per cent. to 95 per cent., according to the class of engine and accuracy of construction.

Engines are tested for steam consumption in connection with steam boilers. Water is measured into the boilers before and during test, and the residue measured afterwards. From these figures the amount of steam used over a prescribed time may be easily obtained, and reduced to pounds per I.H.P. per hour; the usual result is 18 lb. to 22 lb. for compound and triple-expansion engines, 25 lb. to 30 lb. for condensing engines, and 35 lb. to 40 lb. for ordinary non-condensing engines. Better figures are frequently obtained, but the above represents good average practice. Gas and oil engines are tested in a similar manner to steam engines for indicated and brake horse-power, the efficiency being about 85 per cent. Gas consumption is stated in cubic feet per I.H.P., and can easily be measured on the meter for any given period; 15 cubic ft. to 25 cubic ft. of town gas is usual. Oil consumption for oil engines is reckoned in pounds per I.H.P., the ordinary results being from ½ lb. to 1 lb. per I.H.P., according to size of engine and class of oil. Suction gas engines are tested also for fuel consumption, as they are part of a complete gas plant; the I.H.P. is taken at intervals, and the fuel consumption noted for a given time. An average result with a good plant is 1 lb. of coal per horse-power hour.

Testing of Electrical Machinery. Tests to determine the power required by electrically-driven machinery are made by measuring with an ammeter and a voltmeter the electrical horse-power rate of working. If these instruments are not permanently fitted to each motor, the arrangement shown in **360** for inserting portable instruments at the motor switchboard

may be provided. W1 W2 are the cables entering and leaving the terminals of the + main fuse F. Terminals, with milled nuts, T1, T2, are connected by wires W3, W4. When a reading is required, the terminals of a portable moving-coil type ammeter are connected across T1, T2.

When this connection has been made, the fuse F is removed, and the ammeter will then read the current passing to the motor. When the reading has been obtained the fuse is replaced, and the instrument may then be taken out, care being, of course, observed to use insulated tools, to prevent the risk of shock to the operator. The voltmeter is also connected as shown, being attached to both + and − cables. It is thus unnecessary to stop the motor to insert or remove the ammeter. An "efficiency curve" should always be supplied by the makers of the motor, showing its efficiency at various loads. The B.H.P. being delivered to the machine can then be calculated.

Thus, supposing the motor *input* to be 32·5 amperes at 230 volts, and that to be the full load rating of the motor:

$$\frac{32·5 \times 230}{746} = 10 \text{ E.H.P. input to motor.}$$

The efficiency curve showing 86 per cent. at full load, we deduct 14 per cent. inefficiency loss, and get:

$$10 \text{ E.H.P.} - 1·4 = 8·6 \text{ B.H.P.},$$

output to the driving of the machinery.

We also get the approximate mechanical efficiency of the machinery driven. The machine is first run unloaded, and a reading obtained, say, 4 E.H.P., then:

Efficiency of motor at 4 h.p. = say, 75 per cent., then B.H.P. = 3.

Full load of machine takes 8·6 B.H.P. Then

$$8·6 - 3 = 5·6 = \frac{5·6 \times 100}{8·6}$$

= 65 per cent. mechanical efficiency.

Horse-power & Rating of Motors. The horse-power that can be obtained from a motor depends upon its speed and the current which it takes. As the load upon it is increased, the current rises and the speed of the motor falls slightly in a shunt or compound, or more markedly in a series-wound motor. The limit of safe load depends chiefly on the heating up of the field and armature coils in a series motor, or the armature windings in a shunt motor, which must not be so great as to overheat the wires and damage their insulation. Thus, for motors running continuously a run of six hours at full load, or of 12 hours under variable load should not raise the temperature of their windings more than 60° F. Motors for intermittent work, however, where the load is in regular alternations of light and heavy value, as in rolling mills, shears, etc., may be worked at higher rates; while for such work as that of cranes, hoisting machinery, capstans, etc., where load is followed by rest periods, a temperature rise of 75° F. after six hours full load test, or 90° F. after six hours under working conditions, may be allowed. These tests are taken immediately the motor is stopped, by laying thermometers, covered over by dry cotton-waste, upon the field and armature windings, and noting how far the mercury rises, having previously noted the temperature of surrounding air.

Cost of Power. In the absence of an "energy meter," an idea of the cost of running the motor may be obtained. Take a number of readings, say every 15 minutes for an hour or two when the motor is doing a normal load, by the ammeter and voltmeter. Then take the mean of each and reduce to watts. Thus, supposing the mean reading over two hours to be 32·5 amperes, 230 volts. Then

$$32·5 \times 230 = 7475 \text{ watts or } 7·475 \text{ kw.}$$

$$\text{Kw.} \times \text{time} \times \text{price per unit} = \text{cost of power.}$$

Thus, with power, say 1·5d. per unit, in above:

$$7·475 \times 2 \times 1·5 = 22·425\text{d.},$$

or 11·2d. per hour, at the average load of motor.

Insulation. A rough and ready insulation test for a motor is made by connecting a voltmeter momentarily first from the + brush to earth, and then from the − brush to earth while the motor is running. If the insulation is good there should be no reading. If there is a reading, either + or − side exceeding 3 per cent. of the working voltage, the motor should be carefully examined, and it and the circuits tested with proper instruments until the faulty spot is located and repairs effected. Faults in the insulation do not simply mean small leakages and waste of current. The chief danger is that once started they rapidly develop until complete breakdown occurs, and the motor has to stop, also because sparking and arcing take place at the point of failure and may result in fires or other damage, and persons handling the machinery may receive electric shocks.

Testing-rooms. In a modern works the testing-house is completely equipped with appliances for ensuring accuracy, and is a great advance on the testing done in the workshops. A brief notice of the testing-room [**361**] of Messrs. Belliss & Morcom, Ltd., makers of high-speed engines, will give an idea of what the equipment involves. It is a large building, served by several electric travelling cranes. Massive cast-iron slabs are let into the floor on which engines to be tested are bolted. Steam and exhaust pipes are laid down from which connections are made. They are arranged with shut-off valves at intervals, so that an engine can be connected and disconnected without interfering with any other engine under test. Four Babcock and Wilcox boilers supply steam at 250 lb. pressure per square inch. There are several condensing plants. A system of tanks is provided for measuring or weighing the water used by the engines. A number of Crosby indicators are employed. Electrical instruments form a large portion of the equipment. Switches and instruments with wire frame and water resistances enable currents and voltages to be measured up to 1,000 electrical horse-power, for both continuous and alternating currents. The men who make the tests do nothing else, becoming specialists in this work.

Workshop Practice concluded, followed by
TOOLS

BANKING

Credit and Foreign Exchange. Transition from Barter to Credit. Coinage. Credit Documents. The Clearing House System

Following on CLERKSHIP from page 3920

By R. LAING

THE commodities in which it is the business of a bank to deal—money and credit—form the subject of a most important section in political economy, and, before discussing the functions and practice of a banker, a brief survey of their origin and development will not be out of place.

Barter. Barter is the direct result of division of labour. In a community in which each individual wholly supplies his own needs no exchange of commodities is necessary; but if A devotes his sole attention to the manufacture of shoes, he will, in a very short time, completely satisfy his own want of footgear, and be possessed of a stock which is (to him) without value, while at the same time he is aware of a painful lack of the other necessities of existence. However, B, the hatter, C, the shirtmaker, D, the grower of corn, and their fellows, are in a like condition, and, after a certain amount of bargaining, each rids himself of that which was to him superfluous and valueless, gaining in exchange that which is to him necessary and of, perhaps, great value.

The operation of barter creates values in exchange, or prices, which are solely dependent on the current supply and demand. These two factors are, however, subject to several influences. For instance, they must be effective. The tramp may greatly desire the motor-car of the millionaire which passes him on a country road, but he cannot make his demand effective; while the millionaire may strongly wish to be possessed of the tramp's digestion, which, however, the latter cannot effectively supply. Prices, again, do not depend on utility, and vary greatly in differing circumstances. The most extravagant amounts may be given for old curios, which, shipped to Greenland, would command little more than the price of inferior firewood.

Defects of Barter. Barter is at best but a clumsy method of exchange, in consequence of:

1. The need of double coincidence—that A should desire shirts for shoes, and C shoes for shirts;
2. Exact settlement being almost impossible—if one shirt is worth two pairs of shoes and C has only need of one pair, no exchange is possible;
3. The ratios of value being practically innumerable, causing immense difficulty in the settlement of each transaction.

As a result, in every State whose commerce has obtained any measure of importance, a common medium of exchange has been adopted.

This medium is termed money, or currency, and the functions it performs are three in number: (1) It is a measure of values; (2) it is a medium of exchange; and (3) it is a standard for deferred payments.

As 1 it reduces the ratios of value to the number of commodities for sale, less one—itself. As 2 it disposes entirely of the necessity for double coincidence and of the difficulty of settlement, while as 3 it enables the payment in the future of debts now incurred to be carried out with justice to both parties. Supposing a 5 per cent. loan to be made for a year in the form of 100 hats, but that during the year hats become very much less difficult of manufacture. The labour embodied in one hat has been reduced to, say, half of that formerly represented by it, while that necessary for the manufacture of other commodities has remained stationary. In consequence, one hat only exchanges for one-half of the commodities it was worth before, and the lender will not be satisfied with the return of 105 hats at the end of the year, but will ask for 210. The commodity chosen as money requires at all times to possess as far as possible an equal purchasing power.

Upon the greater or lesser degree in which the commodity chosen as money possesses the following essentials depends the efficiency of its performance of the foregoing functions:

(*a*) Utility and intrinsic value.
(*b*) Convenience in size and weight.
(*c*) Indestructibility.
(*d*) Equal sizes and weights to possess always the same value.
(*e*) Divisibility without loss of values.
(*f*) Stability of value.
(*g*) Ease in recognition by all.

It has been found that the metals, more especially gold and silver, possess in the greatest measure the essentials mentioned above, while the State, in accordance with almost universal custom, gives to the public by a system of coinage a guarantee of weight, fineness, and value. In doing so three courses are open to it: all metal may be coined free of charge; a slight charge equal to expenses may be made; or a large profit may be obtained by the issue of a debased or a token coinage.

Standard and Token Money. In every coinage what is termed a standard coin, or coins, will be found—that is, the unit or its divisions, by which all values are reckoned, the standard coins of this country being the sovereign and half-sovereign. These two coins are *Legal Tender* for any amount—*i.e.*, they must be accepted in payment of debt, however large the sum in question may be. Retail transactions require, however, coins of smaller

value, and, as further division would result in inconveniently small gold coins, recourse is had (in this country) to the issue of silver and bronze tokens, which are not regarded as divisions of the standard unit, but act as it were as counters in place of these, occupying very much the same position to the standard coin that the beans of card-players, desirous of obtaining the excitement of playing for seemingly large sums, do to the pence for which, perhaps, a score of them afterwards exchange. Both silver and bronze coins issued by the Mint come within the third class, and both are only legal tender to a limited extent—£2 and 1s. respectively.

In the establishment of a system of coinage it is by no means necessary that the State should confine its standard coins to one metal, but may enact that coins of different substances may circulate side by side, either at a fixed or at a varying ratio, and be equally available as legal tender. The double standard has been brought prominently before the public by the advocates of bimetallism.

Credit. Credit may be briefly described as a commercial lubricator, its absence having the same effect on commerce as the omission to apply the oil-can has on the powers of an express locomotive. It is not material wealth, but rather a transfer of it—*e.g.*, the existing mass of material wealth is not increased when a merchant hands over certain goods to another in exchange for a promise to pay at a future date. Credit allows material wealth to be employed to better advantage, and may release for the actual production of commodities that which was formerly engaged solely in their exchange. The advent of commerce having established in turn barter and coined money, its progress creates a growth of credit, and credit substitutes for coined money, until, as in this country, the transactions which are carried through by their agency far exceed in amount those in which the older medium is still used.

With their introduction, a new factor came into being. A seller who receives in settlement so many sovereigns will be quite assured that he can at any time exchange these for whatever he may desire, but he who takes in payment a paper promising to pay three months hence knows that ere that time comes the paper may be valueless, and, consequently, before taking it, he satisfies himself as to the stability and reputation of his debtor.

Credit Movements. In the course of business each merchant will usually become liable for a large sum, for the payment of which (although his assets may greatly exceed his liabilities) he is dependent on the due settlement of similar accounts owing to himself by other traders. The banks will also be due enormous amounts to their depositors, most of which has been lent out at interest. In the ordinary course of events all will go well; but from time to time a suspicion may arise, either rightly or wrongly, regarding one or more merchants, who, in combating it, will be called upon to prove their solvency by the payment of their liabilities. They may be able to do so by drawing upon their bank balances, or by arranging fresh loans; but, on the other hand, the matter may go further. Suspicion continues to spread, failures occur, universal distrust arises, and each one, fearful lest he may be the next called upon to establish his stability, takes precautions and endeavours to raise from his banker the amounts he deems requisite. The latter, however, is just then seeing his deposits diminishing, his reserves of coin disappearing (to make up the increased amount of money required for use), and finding that his securities are unsaleable and the debts due to him unrealisable. In short, unless confidence is restored, or a remedy found, a financial panic is imminent. The remedy for this country is dealt with later in connection with the Bank of England Discount Rate.

Credit Cycles. The recurrence of such crises as the above occur at well-marked intervals. The bank reserves of a country may be high, universal confidence is felt, interest is low, loans can be obtained without difficulty—"money is easy." An element of speculation creeps in—encouraged, perhaps, by the anxiety of banks to lend their surplus funds—and rapidly spreads, until one day some speculators cannot meet their engagements; suspicion soon becomes rampant, and a panic results.

We have now to consider the various forms of *Credit Documents*. The substitutes for coined money divide themselves into five classes: (1) Note Issues; (2) Cheques, drafts, etc., payable on demand; (3) Currency Bills; (4) Book credit; (5) Clearing Houses.

Note Issues. Notes fulfil in a greater measure than any of the other substitutes the functions of money, being in a manner a convenient form of large token money. The methods of issue are many and varied: they may be either convertible or inconvertible, issued by the State or by certain privileged institutions, with or without restrictions.

What are known as *Convertible Notes* take the form of a promise to pay the bearer on demand a certain sum in standard coin, and against such issues an amount in coined money is held as a reserve. If the issue is unrestricted this amount will not equal the total issue, but will only represent that proportion which experience shows is necessary to meet possible demands in the ordinary course of business.

Inconvertible Notes are simply circulating I O U's with a safety margin, no obligation being imposed on the amount mentioned on each note. They may be quite unobjectionable if certain precautions are observed, but in every case they possess a dangerous tendency to over-issue. They are invariably the result and sign of Governmental financial difficulty, the odium of fresh taxation being avoided by the receipt of the forced loan obtained through their issue. The results of inconvertible notes issued to excess are dealt with in a succeeding paragraph.

Regulations as to Note Issues. The regulations imposed by the State on the issuers of convertible notes may remain unaltered even although the notes are made inconvertible, the only difference being that the obligation to pay in standard money on demand is deleted. The issue of each class may be limited to a certain amount, a minimum reserve may be stipulated for, or a reserve varying with the issue may be required. The reserve may be partly composed of securities, while the limit of issue, if any, may perhaps be exceeded on payment of a certain penalty.

If through certain circumstances there exists in any country a good and a bad currency side by side, in the course of time the former will disappear and the latter become the sole money in use. The explanation is not a difficult one if it is borne in mind that the coins of one country when exported are only worth what they will fetch as bullion. No one would, for instance, export our silver token coinage to France so long as twenty shillings (which, when coined, can be exchanged for one sovereign) are only worth about half-a-sovereign when melted down. The coins chosen for export are those of the fullest weight and of the greatest value; the inferior ones being again issued, to circulate by force of law at a rate above their intrinsic value.

If the convertible issues of any country are beyond what are essential, they will be cancelled by being returned for payment to the issuing banks by the other institutions into whose hands they come. No such cancellation is possible in the case of inconvertible notes, which continue to circulate until they can be used by some debtor of the issuer in payment of his debt.

Provided they can be readily exchanged for their face value in gold, no great harm can be said to be done, and if a large issue is made without this exchange becoming impossible, it follows that the currency was formerly insufficient for requirements. An increase of inconvertible notes, without depreciation, results in a rise in prices, and as the notes are readily exchangeable for their face value in gold, encourages imports from foreign countries. At the same time exports will be discouraged—goods which, owing to the rise in raw materials, are now more costly of manufacture commanding abroad but the same price as before. This encouragement of imports and handicap to exports (which will also be brought about by an excess of purely metallic currency) results in an unfavourable exchange and a probable export of bullion. We shall refer to this later under Gold Points.

Additional Effect of Over-issue. If the inconvertible notes are, however, issued to excess, they will become depreciated in value and will no longer exchange for their face value in metal. Almost every country furnishes examples of paper documents, which, while actively circulating, would exchange for only a fraction—sometimes a most insignificant one—of the coin they were supposed to represent. By force of law, however, such paper is legal tender in payment of any debt, and consequently no one is so foolish as to pay any sum in coin while he has so cheap a medium to his hand. As a result the whole of the transactions of the country are settled in paper, which becomes the sole currency, the standard coins in circulation no longer fulfilling their function, being bought and sold with paper money as a commodity with a varying price.

The amount of this credit money current at any time varies with the sum of the transactions which it is called upon to settle, while the cash reserves which act as a basis are quite insignificant when compared to the transactions which they support. A large increase or decrease in these can be settled by means of this *elastic* currency without variation in the general range of prices.

Bills of Exchange. The characteristics of bills of exchange place them in a class midway between note issues and demand documents. Issued in a similar manner to the latter, they may pass through many hands before they become due—a practice that is referred to under the heading of the Continental Demand for London Paper.

The form of credit known as *book credit* will be best explained by the example of two merchants—one in this country shipping British goods to an American correspondent, the latter in return sending him American articles. The entries in the books balance each other, and obviate the use of currency in payment, limiting it at most to the settlement of a periodical difference.

The Clearing House system is specially adapted to the settlement of bargains in wholesale markets, Stock Exchanges, between railway companies, or by any body of traders whose number is small but whose transactions are many and large. The example which mostly concerns banking is that of the London Bankers' Clearing House, and an explanation of its operation will sufficiently explain the effects of the whole system.

The London Clearing House, originated by some private bankers, now includes nearly every important London bank, although even now some very large institutions (notably the Scotch banks) are still without the pale of its operations, and consequently clear through the agency of some other bank. The work of the Clearing House is divided into two sections—the country and the town clearing.

Country Clearing. To trace the actual course of a document passing through this clearing will most readily show its working. A, a Bristol merchant, posts to B, a trader in York, a cheque on Bristol which B hands to C, his banker, for collection on, say, Monday. The same evening C posts the cheque to his London clearing agent D, and on the following day it is handed to E, the London clearing agent of the Bristol bank (whose name appears on the cheque), by D at the Clearing House, and forwarded the same evening to Bristol, where it is received on Wednesday. If the document had been received on Tuesday by the Bristol banker (F), *direct* from the York banker (C), with

instructions to remit the amount, he would possess at law the option of holding over the cheque until the following day, Wednesday. In order that a cheque passed through the London Clearing House may be placed on an equality, this option is, by the clearing rules, not permissible with cheques passed through the clearing. If unpaid on Wednesday, F returns the cheque direct to C, and sends concurrently to E an advice of non-payment. If on Thursday morning this is not received by E, the cheque is assumed to be paid, and the amount is paid by being carried into the town clearing of that day, the operations and settlement of which are dealt with in the next paragraph. The necessary entries are passed by the banks concerned through their agency accounts, and the transaction is settled without the intervention of a single coin

Town Clearing. To deal with the clearing a separate department is formed in each clearing bank, and to this department is handed all documents which can be passed through the Clearing House. These they enter under the headings of the other clearing banks, the total received during the day being afterwards agreed with the other departments. After being thus entered, the documents are forwarded by messenger to the Clearing House in Post Office Court, and there handed to the representative of the bank on whom they are drawn, and by him entered in a similar manner. At the close of the day the books written up at the offices of the delivering banks are compared with those made up at the Clearing House by the representatives of the receiving banks.

When the various balances have been agreed and any returned documents from head offices accounted for, the representative of each bank enters on a form provided the balances due to or by his bank to each of the others, bringing out the final balance either due to or by it. The final balances thus arrived at must liquidate each other. Each clearing bank keeps an account at the Bank of England, and a settlement is accomplished by the debtor banks paying into a special settlement account at the bank from their own accounts the amounts due by them, and from this account the sums due to the creditor banks are taken and credited to their accounts by the bank. In this way the settlement of transactions to the extent of £12,287,935,000 was in 1905 effected without the agency of a solitary penny piece. The offices, cheques drawn on which are included in the town clearing, comprise the head offices, the City branches, and most of the suburban ones.

Internal Trade. The natural advance of commerce in any country results in the territorial division of labour, some counties, by reason of natural resources, devoting themselves to those industries in which the expenditure of a large capital is necessary, while that required for those peculiar to other parts may be comparatively small. Assuming an equal rate of profit in either case, it will be found that while in the second class the resulting surplus cannot be employed in the place of origin, the first class, so far from being in this position, can actually utilise the surplus of the second. In addition to the consequent constant flow of capital from one part of the country to another the actual trading business may, in certain instances, have a somewhat similar effect. For example, a manufacturing town (whose productions are exported to foreign countries) purchasing the raw materials required in some other part of the country, will be constantly in debt to that locality from which it draws its raw materials. The methods by which the necessary transfers are made will be treated when dealing with the Branch System.

International Exchange. The factors in the trade between any two countries, and the methods of settlement, present a greater complexity than those relative to internal trade. At the outset we find that in nearly every case the currencies employed are dissimilar, and that between two countries possessing the same standard there exists what is termed a *Mint Par*.

This is a figure which represents the ratio between the amount or weight of fine metal contained in the standard coins of the two countries in question, the mint par between this country and France is 25·2215 simply meaning that in 25·2215 francs in French gold coinage there is contained the same amount of fine gold as in an English sovereign. A mint par is mechanical and fixed, and can only exist between countries possessing the same standard.

There are four individuals in each exchange transaction. The truth of this phrase will be apparent from the following example. If A in Paris owes X in London £100, while Z in London owes B in Paris an equal amount, the double indebtedness will be cancelled by B drawing a bill on Z, which he sells to A for a certain number of francs, and which, after being remitted by the latter to X in payment of his debt, is paid on presentation by Z, who thus satisfies his debt to B through the medium of A and X. This is, in substance, the working principle of every foreign exchange transaction, the only possible difference being the increase of the parties intervening between Z and B.

Gold Points. Assuming the indebtedness of the countries to be equal, the resulting equality of supply of, and demand for, bills will cause the sight rate to be quoted at the mint par. If, however, it occurs that in Paris there are more debtors than creditors of this country, the demand for bills will exceed the supply. Those indebted to London have two methods of payment open to them—they may either remit bills purchased in Paris, or they may ship sufficient bullion to liquidate the debt. The latter course will entail a certain expense, say of 10-12 centimes per £; so that to put down in London 25·2215 francs in French gold coinage, equivalent to one sovereign, the merchant in Paris will expend 25·3215 or 25·3415 francs.

He will certainly not do this if he can purchase a bill on London for £1 at a better rate, and accordingly the matter resolves itself into a struggle between buyers and sellers, in which the price of a bill for £1 on London (expressed in French francs) continues to rise until it reaches

that point at which it is as profitable to ship bullion, unless in the rise a sufficient number of buyers drop out, hoping for a more seasonable opportunity, or a number of dealers in arbitrage [see later] enter the market as sellers. An excess of creditors of London in Paris would, of course, influence the exchange in the opposite direction.

Gold Points not Fixed. The two gold points between two gold standard countries can only be determined approximately, the cost of shipping and insurance varying, while other influencing factors may exist. The point at which gold leaves France and Germany for this country is, owing to certain restraints exercised by them, less easily reached than that at which gold leaves us for them.

If the rate of the French exchange should be quoted in the money column of the newspapers as approaching the point at which gold will leave this country for France, the City editor will no doubt remark upon its *unfavourable* aspect; while, if the rate is given as 25·25, he will refer to it as being in *our favour*. These terms owe their origin to an exploded theory in political economy, but their present meaning and significance is wholly wrapped up in the fact that, when there is no danger of gold leaving this country reserves will be high, interest low, and trade encouraged; while, if an export of bullion is threatened, an entirely opposite state of affairs will exist. The subject is further treated in dealing with the Bank of England Discount Rate.

The main elements in "International Indebtedness" are the imports and exports between the countries concerned, but in the case of nations such as ourselves, possessing a large amount of shipping, freights earned by such shipping affect very greatly the balance of trade. A British vessel transporting a cargo of machinery to Hamburg will, if the transaction is to be completely settled, require on the return voyage to carry a quantity of, say, grain, that will, when realised, liquidate the claim of the British engineer and the shipowner's charges for the *double* voyage. The vast sum of money invested abroad by this country possesses also a great influence on the exchanges.

Effect of Loans on Exchanges. The lending country may remit to the borrowing country the amount of a loan in one or all of three ways—either by the export of some products or bullion, or by the extinction of an already existing floating indebtedness. The effect on the exchange in each case will be exactly similar—it will become more favourable to the borrowing country; but, on the other hand, when the first instalment of interest is due, and on each subsequent payment, the exchange will be influenced in favour of the lender.

Other influencing factors comprise subsidies, indemnities, expenses of foreign travel, the cost of fleets and garrisons in foreign stations, and the purchase and sale of foreign securities. In addition, one important factor remains—namely, the operations of arbitrage. If some dealers in exchange in Paris are of opinion that in the future the London sight rate will fall greatly, they will, by arrangement with their London correspondents, sell largely bills drawn on the latter, hoping to be able to extinguish the overdrafts thus created by purchases at a cheaper rate. If an arbitrage firm are able to sell a bill for £1 on London for 25·27 francs, and next week buy a bill for the same amount (to recoup their London friends) for 25·20 francs, they will have gained a profit of 7 centimes per £1, less interest, etc. In doing so, they will, in the first place, reduce the high rate by selling, and, secondly, raise the low rate by buying.

Position of the Banker in Commerce. The functions of the banker in commerce are very much akin to those of the mortar employed in the construction of a large building, without which somewhat insignificant-looking agent the gigantic fabric would be non-existent, for in like manner the bank officials in this country, in the performance of what is largely commonplace routine, cement together the trading communities of the whole world. So great is the dependence of present-day commerce upon the facilities and conveniences afforded by banking institutions that even the total destruction of our railways would not equal the effect produced by the complete cessation of banking business. Banking may be considered, according to the inclination of the individual, either a trade or a profession, but in reality the former term is more correct, for, although not actually dealing with the products of commerce, the banker trades in the commodities on which commerce is dependent—money and credit.

Functions of a Banker. The most widely spread of banking functions is the practice of note issue. In all new countries—even though they be possessed of unrivalled natural resources—there is usually felt a lack of circulating medium. The expenditure of a large amount of their available capital in the establishment of a system of metallic currency does not meet with any favour in their eyes, while at the same time the opening of branch banks in a sparsely-populated country is rendered impossible on account of expense. To all such countries a good note issue, more especially a carefully-managed unrestricted one, is of the highest value, combining in itself at one and the same time an economical currency, a convenient form of internal remittance, and a factor in production which, although in itself valueless, may be the means of laying the basis of a far-reaching commercial greatness. [See Scotch Banking.]

The system in vogue in France at the present day partakes of this form to a great extent, while that function which is most in evidence in banking in this country (that of deposit) is comparatively neglected, the issues of the Bank of France taking the place occupied in this country by the cheques of private individuals.

Continued

Group 19

JOURNALISM

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FIRST STEPS IN JOURNALISM

Fitness for Journalism. How the Candidate may Test Himself. Opportunities on the Local Papers. Helpful Exercise. Preparing the Way for a Successful Career

By ARTHUR MEE

THERE are many gates through which the candidate for journalism may enter the profession. So simple is the passing through them that the ways and means of doing so need only brief mention. They will be apparent to the young man destined for journalism, the young man of more than average capacity, and it is entirely with him that we have to deal.

The First Thing to do. For journalism has no room for men whose mind and character are not above the average; no room, at any rate, at the top.

We have nothing to do here with the young man who wants to muddle through. The SELF-EDUCATOR is conceived and edited and written for the young man who believes that whatever he does is worth doing successfully, that if he is not doing it successfully he had better leave it alone and succeed at something else; and this course of journalism is written for the young man who would be a journalist in earnest, who wishes to be somebody worth being, and to do something worth doing.

To this young man, as he looks round on leaving school and makes up his mind to be a journalist, the course will be clear. He should get at once into touch with the nearest editor.

The very obviousness of this is one of the most wonderful things about the career upon which he is entering. If he had made up his mind to be a doctor, or a lawyer, or an architect, and the SELF-EDUCATOR had not come into existence to help him, he might have been bewildered by the difficulty of obtaining the simplest information, the expense of examinations, and the long period of waiting.

But it is safe to say that there is not a young man in England with the possibility of becoming a journalist into whose home there does not come at least once every week the very vehicle through which he may set out for his goal. We have discussed the democracy of journalism, and there is no more remarkable thing about this fascinating career than this, that we can train ourselves for it in our own homes, in every day that we live; that wherever we are we may equip ourselves for it, without any conscious effort, by ordering our lives naturally and reasonably and well. No course at a college is necessary, no costly period of apprenticeship. The training of him who would be a journalist is in his own hands.

The Study of Local Life. What, then, is the first thing that he should do? He should study the local papers and familiarise himself with the things with which they deal. He should make it his business to understand the village or town in which he lives, to let nothing happen in it of which he does not know; to interest himself in all its social and industrial developments; to be in touch, somehow, with all its active movements. He should lose no opportunity of discussing any subject of local interest. He should learn to understand the various points of view, the ideas that lie below things, to know the interesting personalities in local affairs, and what they stand for. The life of the town is the best training-ground he could possibly have, and by taking full advantage of the opportunities it affords, he will be living naturally and preparing himself at the same time for his career.

There are, of course, various definite preparations that he should make. He will naturally have learned shorthand. Any boy of average intelligence can learn shorthand from the SELF-EDUCATOR in six months. He will have thoroughly grounded himself in grammar at school, have mastered the art of punctuation, have learned to write plainly and without flourishes. He will read books as well as papers, and will not waste the time he should spend in study in watching men kick a ball about. He will not turn to the sporting page the moment he takes up a paper, but will have a sense of the real value of things, and know that a consuming passion for sport is his enemy.

What to Read and Learn. Such things as these must be obvious from the very beginning, and it will help him greatly to study the scientific and literary sections of the SELF-EDUCATOR. He cannot, indeed, be too strongly advised to study this book closely, with special attention to the following subjects:

BIOLOGY	RELIGION	IDEAS
PSYCHOLOGY	CHEMISTRY	LITERATURE
SOCIOLOGY	GEOGRAPHY	PHYSICS
LOGIC	HISTORY	PHYSIOLOGY
PHILOSOPHY	APPLIED EDUCATION	TRAVEL

It need not be said that a sound knowledge of his own language is essential, and he will do well, even if he possesses this, to study the course on English in the EDUCATOR. If he can learn French and German, too, he will add greatly to his opportunities; at any rate he should learn French. The value of a knowledge of languages is so apparent that it is not necessary to emphasise it; but it is strange that editors should feel more and more the necessity for emphasising the importance of a knowledge of our own language. It is an amazing thing that the number of people who can write a sensible and interesting letter is only a small proportion of those who would be hurt not to be called educated; and an editor's experience compels him to believe that the average man finds it exceedingly difficult to express himself clearly in writing. It is a common-

place that men whose conversation is packed with interest are often unreadably dull when writing, and the young journalist cannot regard this subject too seriously. It is the very essence of successful journalism that a man shall be intensely interested in things, and shall be able to make other people as interested in what he knows as he is himself.

The Art of Expression. The question of "style" in writing can be left to settle itself. If a man does not write plainly he will soon discover the fact by finding that journalism does not want him; and if he, a round man, insists upon trying to fit himself into a square hole he will be entirely to blame for the consequences. We shall have to discuss this question later; it need only be touched upon here to explain how the journalist may help himself to master the art of literary expression.

He will find the best opportunities for doing so in the local papers themselves. He is almost sure to find, wherever he is, one paper that gives long accounts and another paper that gives short accounts, and he will find it a very profitable exercise to take the long account of a ceremony, or the long report of a speech, from the one paper, and condense it to the length of the short report in the other paper. Let him take a column and condense it to a paragraph, without losing any vital point of argument, and with as little sacrifice of interest as possible. He should learn, also, to summarise a speech in longhand, writing it as it is delivered, and for exercise of this kind he will find a knowledge of the abbreviations used in journalism of great service. We come to them in the next few pages.

The question of personal fitness for newspaper work will decide itself quickly for the young man who is sensible enough to realise his own capacities or honest enough to recognise his limitations. But it will save a great deal of disappointment if the candidate for journalism tests himself in some main points before seeking to enter the profession. There are some specific tests we may quite easily apply to ourselves.

Object Lessons. We may make a newspaper an object-lesson—may ask ourselves if, had we edited the paper, we would have passed this or sanctioned that? We may compare the length of two articles, and form our own opinion of their comparative values. We may consider the appropriateness of the headings, and ask ourselves if we could improve upon them. We may compare papers, and note where one succeeds and the other fails; we may study them closely and discover for ourselves the reason why people buy one and not another. Best of all, we may prepare our own map of the life of the town on any given day or in any given week, and compare it with the corresponding daily or weekly paper. It is possible to obtain quite an intimate knowledge of the way in which newspapers deal with events by constant exercise of this kind.

The regular practice of shorthand is essential, and no better method of practice can be devised than constant attendance at public gatherings of all kinds. The young journalist should never fail to take advantage of an opportunity of making notes. His notebook and pencil should be as essential a part of his outdoor equipment as his hat. He should take down speeches and sermons, and it will be better still for him if he has opportunities of making notes of conversations. If he has friends who are interested in his progress, they could, perhaps, do him no better service than to let him interview them on some topic in which he and they are interested.

Early "Copy." Another experience the young journalist may give himself will be very useful to him one day if he practises it early. He should learn to write exactly a column of his favourite newspaper, or exactly a paragraph. One of the most elementary faults of incapable journalists is the inability to write as much as they are told to write, and no more. It is surprising to find that even qualified writers when asked for a 1,000 words will often write 1,500, and if asked for a paragraph will write half a column.

Every day will bring its own events for the journalistic mind to exercise itself upon. The things of universal interest are the things that the average man talks about, and the young journalist should write a short account every day of something he has heard, or seen, or perhaps read. He should make it his business to discover the most interesting aspect of all that happens.

He will find, if he belongs to the elect of journalism, that the thought will constantly come to him, "Here is copy for a paper," and at all such times he will make a note and write a paragraph. These paragraphs he will submit to the editor of the paper in which he is most interested, to whose columns he has adapted them. There will in this way grow up between him and the editor a channel of interest which will serve him better than any introduction when he comes to seek an actual engagement.

In Touch with the Editor. He will find that the connection thus established is the best of all possible introductions to a newspaper, and he will find, if he lives with his eyes open, abundant opportunities of helping the paper by sending reports of events which it has missed through not being notified. If he is identified with a church or chapel, with a trade organisation, or with any social movement, occasions for giving the paper such help will be by no means few or far between. The time will probably come when, on a busy day, the editor will want special help, and his inclination will be at once to call upon his outside contributor. If he should live in the country he would have no difficulty in obtaining an appointment as local correspondent at a fixed rate of pay measured by the work done, usually a penny a line for all that is published, with a minimum payment of half a crown. If he should live in the town where the paper is published he may have to wait longer, but an enthusiastic cultivation of opportunities will bring its reward at last. Hardly a day passes in which it is not possible for a young man with the ability to write to send in an acceptable paragraph to a paper.

Education by Travel. The young journalist need not trouble about a university education. He need not despise it if the opportunity should come to him, but if he should have the choice, say, of going to a university or of travelling for a year, he will be wise to travel. "The only thing against him," a newspaper proprietor said in discussing an applicant for a post, "is that he has been to a university." And it was merely an extreme way of putting the truth that a university career does, unfortunately, too often detach a man from that side of life which comes very closely into journalism.

The opportunities of popular education are so great in these days that no man need go to a university to become a successful journalist, and it is impossible that two years in any university can contribute to his capacity for journalism anything at all comparable in value with the result of two years of contact with men and affairs, or two years of actual experience in a newspaper office.

Having assured himself of his fitness for the work, the young journalist will not wait for an opportunity to present itself. He should write to the local editor as soon as he feels that he has any real capacity to justify him. If he is fortunate, he will probably be asked to call and serve a little while on trial, preliminary to becoming an apprentice. He should accept a proposal of this kind with great satisfaction. Once the gate is open, his future lies with himself.

But he should pay no premiums; and in no circumstances should he pay down a sum of money for the privilege of learning journalism. The offices in which this would be insisted upon are seldom capable of teaching journalism. Nor should he become—unless, perhaps, in some small town it may be quite inevitable—a "reporter-comp," a reporter, that is, who sets up his own copy.

Sleepy Papers. It may be well, perhaps, to prepare the young journalist for some disappointment in beginning his career. He may find himself on the staff of a paper which does not fire his imagination or fill him with any stirring hopes, and he may be inclined to ask himself if, after all, journalism is the mighty thing that it is claimed to be. If he is wise, he will not allow himself to be depressed by any environment in which he may find himself placed. It happens often that a newspaper is the least representative thing in the town in which it is produced; just as it happens that a portrait is utterly unlike the man who sat before the camera. But a bad newspaper is no more a denial of the imagination and power in journalism than a bad photograph is a denial of the possibilities of photography.

The true attitude of a young journalist who is wide awake on a sleepy paper is one of philosophic patience. He must use the best machine he can find for initiating himself into the mysteries and difficulties and potentialities of a newspaper, and it may, indeed, happen that the very best field he could desire for his earliest work is just such a paper as we have considered. If he is attached to a paper which works him hard and pays him ill, that at least will teach him patience. If he joins a staff which is far too small, that at least will give him opportunities of distinction. If he joins a staff which needs lessons in enterprise, that at least will enable him to display originality.

The Young Journalist's Environment. It is unfortunately true that newspapers are often the commercial property of men who know nothing of journalism, who care nothing for its immense possibilities, its traditions, or its dignities. To many proprietors a newspaper is an article of commerce like soap, and nothing more. There are newspapers which send out ungrammatical advertisements every time they have a vacancy, and there are papers with a hundred glaring faults which we shall discuss in their place. But there are few ideal things in an unideal world, and only a pessimist will allow himself to be utterly depressed by it. And the pessimist has no business to be a journalist.

As sometimes the office in which the journalist finds himself is disappointing, so, too, the atmosphere of local journalism may fill him with despair. Too often it is the atmosphere of a third-rate club, with beer and skittles and a favourite room at a public-house. There is something, perhaps, in the conditions of journalism which brings about this state of things. Long hours, irregular meals, strenuous mental exertion combined often with great physical activity, are not the natural factors in an equable and steady life. But the good journalist will rise above the vulgar conditions in which he will often find himself placed. He will not allow either his pride in his calling or his outlook on life to be prejudiced because sometimes, somehow, it happens that newspaper men write their copy in the back parlour of a public-house and dissipate the hours of sleep in bad clubs and bad company.

The Unprosperous Tenth. General Booth has familiarised us with the idea of the submerged tenth. There is an unprosperous tenth in journalism, to which it is all too easy to belong. Who wants to join it may; it is a characterless army, with no high patriotism to inspire it, no great cause to serve. To it belong many figures sadly familiar in Fleet Street, and in the newspaper haunts of our great towns. No profession, surely, had ever more failures.

The young journalist, however, need not despair. There are sadder things in the world than the wreck of a man who has played with a serious profession. There are sadder things, even, than the man who fails because he chooses a career for which he is unfitted, who takes no heed of the warning which must come while still there is time.

The young man who comes into journalism bearing in mind all that we have considered together, testing himself in the ways we have discussed, full of enthusiasm and hope, eager to pick up an idea, to catch a thought, to feel an inspiration, to know the most that he can know about the best things worth knowing, may go forward without fear. With a full mind and a soul alive he will make his way and reach his goal.

Continued

NAVIGATION OF THE AIR

Balloon Construction. Varieties of Balloons. Gases Used for Inflation. Ascending and Descending. Parachutes. Airships

VEHICLE CONSTRUCTION continued from page 3908

By PERCIVAL SPENCER

As a fish floats in the water so does a balloon float in the air. When the fish distends its air-bladder, it becomes lighter than the water, and rises; when the fish compresses its bladder, it becomes heavier than the water, and sinks. When a balloon is inflated with a gas so that it is lighter than the air, it rises in the air; when it loses some of its gas and becomes heavier than the air, it sinks to the earth.

Air at ordinary temperature weighs 75 lb. for 1,000 cubic ft. Hydrogen, coal gas, and hot air, are all lighter than the ordinary atmosphere, and are used for the purpose of inflating balloons. Hydrogen weighs only 5 lb. for a similar quantity, and is so light that there cannot be much advantage for the purpose of balloon inflation in discovering anything lighter, for the lifting power of hydrogen in air is 70 lb. per 1,000 cubic ft. For economical reasons coal gas is now largely used for ballooning purposes. It has a lifting power of 40 lb. per 1,000 cubic ft.

The system of obtaining levity by means of heating the air itself is practically successful, although it is considerably less efficient than the gases already mentioned. For each degree Fahrenheit that the air in a balloon is raised, it increases $\frac{1}{473}$ in bulk, so that should the temperature be raised 100 degrees the bulk has increased about one-fifth, and has a lifting power of $12\frac{1}{2}$ lb. per 1,000 cubic ft. In practice it may be possible to raise the temperature to 150 or 200 degrees higher than the surrounding air, so that a lifting power of 25 lb. per 1,000 cubic ft. may be obtained.

To lift 70 lb. weight in air a sphere of 1,000 cubic ft. of hydrogen is required 12 ft. in diameter.

Materials for Balloons. The whole bulk of the inflated balloon and its load must be lighter than an equal bulk of air. The simplest form of balloon that can be imagined is the soap bubble. Experiments may easily be made with soap bubbles inflated with ordinary air, or with coal gas, or pure hydrogen. Small scientific balloons are sometimes made of a dry film of collodion, most delicate and fragile articles of 2 in. or 3 in. diameter which ascend when inflated with their quota of coal gas or hydrogen. Indiarubber toy balloons are made in sizes up to 60 in. in circumference. They may be inflated under tension with air, coal gas, or hydrogen, and are suitable for experimental as well as recreative purposes.

Paper Fire Balloons. Tissue paper is used to construct balloons of from 6 ft. to 50 ft. in circumference on the hot-air system. A large aperture is left at the bottom of the balloon, surrounded with a circle of cane or wire. A pad of cotton wadding is attached in the centre of this circle by means of cross wires. When this pad is soaked with methylated spirit and ignited, a flame of sufficient power is formed to heat and rarefy the air in the balloon to such an extent that the balloon readily ascends and, in the case of the larger sizes, is capable of carrying considerable weight.

Gold-beater's-skin Balloons. Gold-beater's skin forms the substance of which the most practical model gas balloons are made. This animal membrane makes a strong, light, and gastight envelope which is easily inflated with ordinary coal gas or hydrogen at the ordinary atmospheric pressure. The skin is used single for the very smallest balloons, for those of from 12 in. to 24 in. diameter. For larger sizes the skins are employed double, treble, or manifold, and are caused to adhere in the process of manufacture in such a manner that the whole balloon appears seamless, however large and thick it may be. Double and treble skin balloons, are made from 2 ft. to 10 ft. in diameter for use with coal gas or hydrogen, and in larger sizes they are used in manifold skin by the British Government for military reconnoitring purposes.

Passenger Balloons. The materials, however, which are usually used for balloons to carry passengers are cotton or silken fabric coated with an oil varnish which forms a film over the fabric and thereby completely closes the pores and enables the envelope to hold gas. A proofing of vulcanised indiarubber is sometimes used; this is gastight, and free from tackiness, but somewhat costly. The varnished fabric is generally preferred owing to the fact that another coat of varnish is easily applied when needed, and renders the balloon again perfectly gastight. The network which is spread over the gas balloon naturally strengthens the material besides achieving its direct object of equalising the strain of the weight which is carried uniformly over the surface.

Hot-air passenger balloons are made of cotton fabric strengthened with webbing sewn over the surface, coated inside with a distemper earth colour, and without the netting of the gas balloon.

Smallest Man-carrying Balloons. We have explained that the lifting power of hydrogen is 70 lb. per 1,000 cubic ft., so that 5,000 cubic ft. will lift 350 lb., and a balloon containing this represents the minimum size that will carry a man. The 350 lb. may be divided up into the proportion of 150 lb. for the total weight of the balloon and its equipment, and 200 lb. for the weight of the man, ballast, and lifting power. This represents a balloon of slightly more than 20 ft. diameter, which must be regarded as the midget of all aerial craft.

For coal gas the irreducible minimum would be 10,000 cubic ft., which is represented by a sphere of 26 ft. diameter. The minimum for a hot-air balloon is considerably greater, and in practice never less than 30,000 cubic ft., representing a vessel of 35 ft. in diameter.

Shape of Balloons. The spherical form is the most natural shape for a balloon. The pear-shaped balloon, comprising a perfect sphere with a gracefully tapered neck, has some advantages of utility as well as appearance, and is frequently adopted.

The obvious advantages of the elongated forms used for navigable balloons or airships are obtained at the cost of considerable increase of surface and therefore of weight.

We shall now proceed to describe in detail the passenger balloon and its appliances. It consists of a number of gores sewn together by a sewing machine, and afterwards completely varnished to render it impervious to the coal gas which it is to contain. Its size varies with the weight it is to carry. In capacity, approximately 10,000 cubic ft. is required for each passenger to be lifted. Taking a balloon, therefore, of 50,000 cubic ft. as a model, this is capable of carrying five persons and a proportionate weight of ballast. It would have a diameter of 45 ft., be constructed in pear shape, and have an aperture at the bottom, and another at the top to contain the valve.

The Valve. The valve [1] consists of a bent ash hoop (A) of approximately 2 ft. 6 in. diameter, made of wood about 3 in. by ¾ in. It has a cross-bar of mahogany (C) which crosses its centre, and to this bar are hinged two semicircular mahogany doors (B, B) which open inwards, somewhat after the style of the wings of a butterfly. Fitting into the bar, and made removable, is a wooden bridge (D) which carries an elastic spring (E, E), and this elastic spring retains the doors in a closed position by means of metallic hooks which pass through eyes into the doors themselves. The effect of this arrangement is that the doors are normally closed.

The valve line (F) is attached to the under side of these doors from two points in each door. The four cords which leave these points join the valve line itself a few feet down, and hence one line only continues downwards through the aperture or mouth, which is always left open while the balloon is sailing in the air, to within reach of the passengers in the car. When the line is pulled from below, the doors are naturally opened, and when the line is released they immediately close by the force of the springs, so that the valve may be opened and closed at the will of those in the car. The valve is attached to the top of the balloon by being firmly whipped on with cords which pass over a collar of the material prepared for its reception. This collar is also strengthened, both underneath the cord and for some distance over the surface of the balloon, by means of an addition of leather which is shaped in regular festoons, and then sewn on. The valve is rendered gastight at the joints by means of "lute," a composition of soap and fat, forced into the crevice so as to seal it.

Netting. Made completely to cover the balloon proper is the net, the object of which is to carry the entire weight that is to be suspended from the balloon. It divides the strain very evenly over the whole surface, and it also plays an important part in the inflation of the envelope, enabling a large number of sandbags to be hooked on, thus retaining and steadying the balloon during inflation. This net is made of Italian hemp, and consists of a large number of meshes, which vary in number with the size of the balloon. In the model we have selected there would be 128 of these meshes. In size they would start at about 6 in. at the top, and slowly increase as they descended, until at the largest point they would be about 12 in. in length, which would make each diagonal nearly 24 in. from top to bottom.

The cordage would slightly increase in strength downwards, being rather lighter at the top than at the bottom. From the bottom of the net the meshes take a somewhat altered appearance, and are lessened in number and greatly increased in length for three rows.

These rows of the network are no longer meshed, but are known technically as *doubles*. From the lower of the three doubles, which are not knotted like the ordinary meshes, but run on brass thimbles, start the 16 leading lines which lead towards the hoop. All the meshes are confined at the top within a circle or grummet of rope, and this is held in position round the valve by means of eight straps, which are securely fastened to the rim of the valve. The net rests evenly all over the balloon, and supports the weight by means of its leading lines, which are fixed over the toggles of the hoop.

The Hoop. The hoop is an important feature of the balloon, and is made strong enough to stand great strains. It consists of bent ash about 1 in. in thickness, by 4 in. wide, formed in a circle of 3 ft. in diameter. Encircling its entire circumference is a woven hempen band, made of a number of cords and known as *sword matting* owing to the fact that when made by sailors on board men-of-war swords were used in its construction. It is simply a webbing, made like ordinary fabrics with the warp and the weft of hempen cordage. Its use is to act as a security in the event of any excessive strain breaking the woodwork of the hoop.

The toggles—shaped pieces of hard wood, which are 16 in number at the top—are attached to small pieces of rope which pass round the wood and sword matting. They afford a simple yet sure method of attaching the net by means of the eyes spliced at the ends of the leading lines being placed over them.

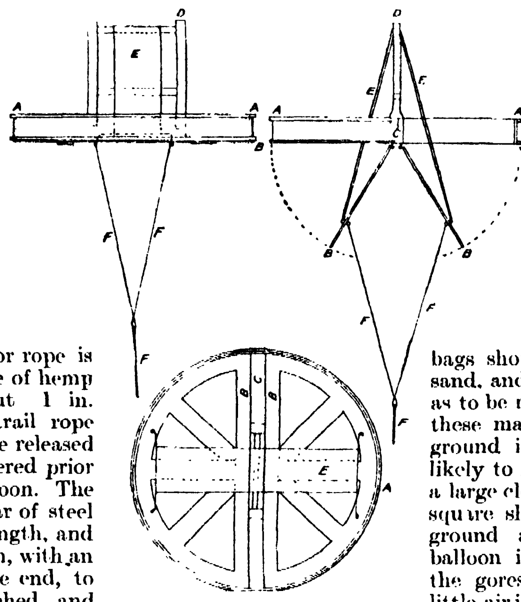
There are ten somewhat larger toggles at the lower portion of the hoop. These are also fixed to circular pieces of rope encircling the hoop, and serve as a means of attaching the ten car lines in the same manner as the leading lines. In addition to the wood, the sword matting, the toggles, and their grummets, the hoop has two

ropes crossing its full diameter at right angles. From each of the joints where these join the hoop, loops are attached to which the grapnel rope, trail rope, captive rope, or any other rope by means of which the balloon is held, can be fixed.

The Balloon Car. The car consists of a rectangular wicker-work construction, measuring, say, 5 ft. by 3 ft., and having a depth of 3 ft. The ten car lines with which it is suspended pass right through the wicker-work underneath the floor and up the two sides so as to form a strong and efficient means of holding the weight. Wooden or wicker seats are slung from loops in the car.

Loops are also provided through which the valve line may be passed, in order to take the strain in holding the valve open. In this car the aerial voyagers sit or stand, and have with them the sandbags containing sufficient weight, more or less, to equal the ascending power of the balloon.

Grapnel and Trail Ropes. On the side of the car is attached the coils of rope which form the trail rope and grapnel rope, the ends of these ropes being fixed to the loops in the hoop above. The length of the trail rope is about 300 ft., while the anchor rope is about 50 ft. long, made of hemp or manilla, of about 1 in. diameter. Both the trail rope and the grapnel rope are released from the car and lowered prior to the descent of the balloon. The grapnel consists of a bar of steel or iron, some 3 ft. in length, and $2\frac{1}{2}$ in. by 1 in. in section, with an oval-shaped ring at one end, to which the rope is attached, and containing four flukes about 1 ft. long, placed at right angles to each other, and of somewhat smaller section than the bar of the grapnel itself. This forms the perfectly equipped balloon, and comprises all the details which are actually on the balloon when it ascends. The other necessary items are the hose-pipe for filling and sand-bags for controlling the balloon during its inflation.



1. BALLOON VALVE
(In section, transverse section and plan)

Ballast-bags. There are required 80 canvas bags, each about 18 in. high and 9 in. in diameter, fitted with ropes and galvanised iron hooks. They are filled with sand and form the ballast-bags. The hose-pipe consists of a varnished calico tube about 75 ft. long and about 10 in. in diameter. It is tied over the gas-pipe by means of tapes and is provided at the end which is to enter the balloon with a zinc tube 2 ft. long and 9 in. in diameter, which enables it to be tied with tapes into the mouth of the balloon.

Inflation. Coal gas supplied by the various gas companies, which passes through the ordinary street mains, is most frequently used. Carburetted water gas is very poor for balloon purposes. The speed with which the balloon can be inflated depends principally upon the size of the gas main which is available at the point of inflation. Through a main of 8 in. internal diameter, such as is laid at the Crystal Palace, 25,000 cubic ft. of gas per hour will pass. This quantity can be made to vary by the pressure put on at the works. A coal gas main 6 in. in diameter would take about double as long to give the same supply as an 8-in. under the same conditions, and a 4-in. pipe again double as long as a 6-in. Great care should be taken before attempting to inflate a balloon through a smaller size pipe than this, as the supply of gas will generally prove inadequate.

Assistance. A low-lying position is to be preferred for inflation, and if the site can be surrounded by trees or other means of protecting it from the full force of the wind, so much the better. It will be found that three or four assistants are required. The first proceeding is to have the ballast-bags filled with sand. If the sand should be stony, some bags should be filled with sifted sand, and in some way marked so as to be recognisable in order that these may be taken up. If the ground is in any way rough or likely to injure the balloon fabric, a large cloth measuring some 50 ft. square should be spread on the ground as a protection. The balloon is then opened out, and the gores carefully unfolded; a little air introduced by shaking the mouth will assist the easy opening of the material. The fabric should be drawn in such a manner that the valve lies in the centre of all, the seam lines radiating from it to its outer margin. The mouth should be placed nearest the gas outlet though the whole balloon may be 30 or 40 ft. distant from this. The folds of material are drawn over the mouth or inlet in such a manner that the inward flow of gas will not be checked.

Spreading the Net. The net is now taken in hand, opened, and carefully spread over the balloon so that the circular grummet at the top finds its place on the valve. This grummet is now strapped on to the rim of the valve by the eight small straps which are fixed thereon. The leading lines at the lower part of the net are loosely spread round the outer edge of the balloon, no particular care being needed to prevent their entangling, as they fall loose as the balloon fills.

Luting the Valve. The luting of the valve is now attended to, and the valve spring adjusted. Now the hose-pipe should be tied on to the gas outlet and on to the mouth or inlet of the balloon. Before turning on the gas it is necessary to attach a certain number of sandbags by their hooks to the network.

Placing the Sandbags. Starting from the hose-pipe the bags should be regularly placed round the balloon about one foot away from its edge [2]. Having settled upon the first mesh to hook the bag to, it is now essential to proceed round the balloon and attach the remaining bags along the same row of meshes, with one bag at every fourth mesh. This will utilise 32 of the sandbags, and the remaining 32 should be placed in readiness about a yard from the balloon and between each of the bags already attached, in order that they may be used in their turn. The gas may now be turned on, and as it flows into the balloon the sandbags will be found to hold the whole system with regularity. At this early stage care must be taken not to permit any creases to remain in the fabric towards the valve, as when the material ascends higher these cannot be removed. When the gas has tightened the fabric all round, it is time to lower the sandbags. This is done by unhooking the bag from its mesh and hooking it on one mesh lower [3].

Final Preparations. When the inflation is nearly complete [4], or sooner if the weather be windy, the hoop must be carried underneath the balloon and the leading lines collected and attached to the toggles. When the sandbags are on the lowest series of doubles, the car should be introduced and attached to the lower toggles of the hoop. The sandbags may now be placed on the leading lines and the balloon permitted to rise clear of the hoop and car until the inflation is complete.

Whenever the balloon is full, the gas must be turned off, and the hose-pipe detached and removed. By looking into the interior of the balloon (care being taken not to inhale the gas), the valve line may be secured, though not tightened, from the top. The mouth may now be closed with a temporary cord or india-rubber ring.

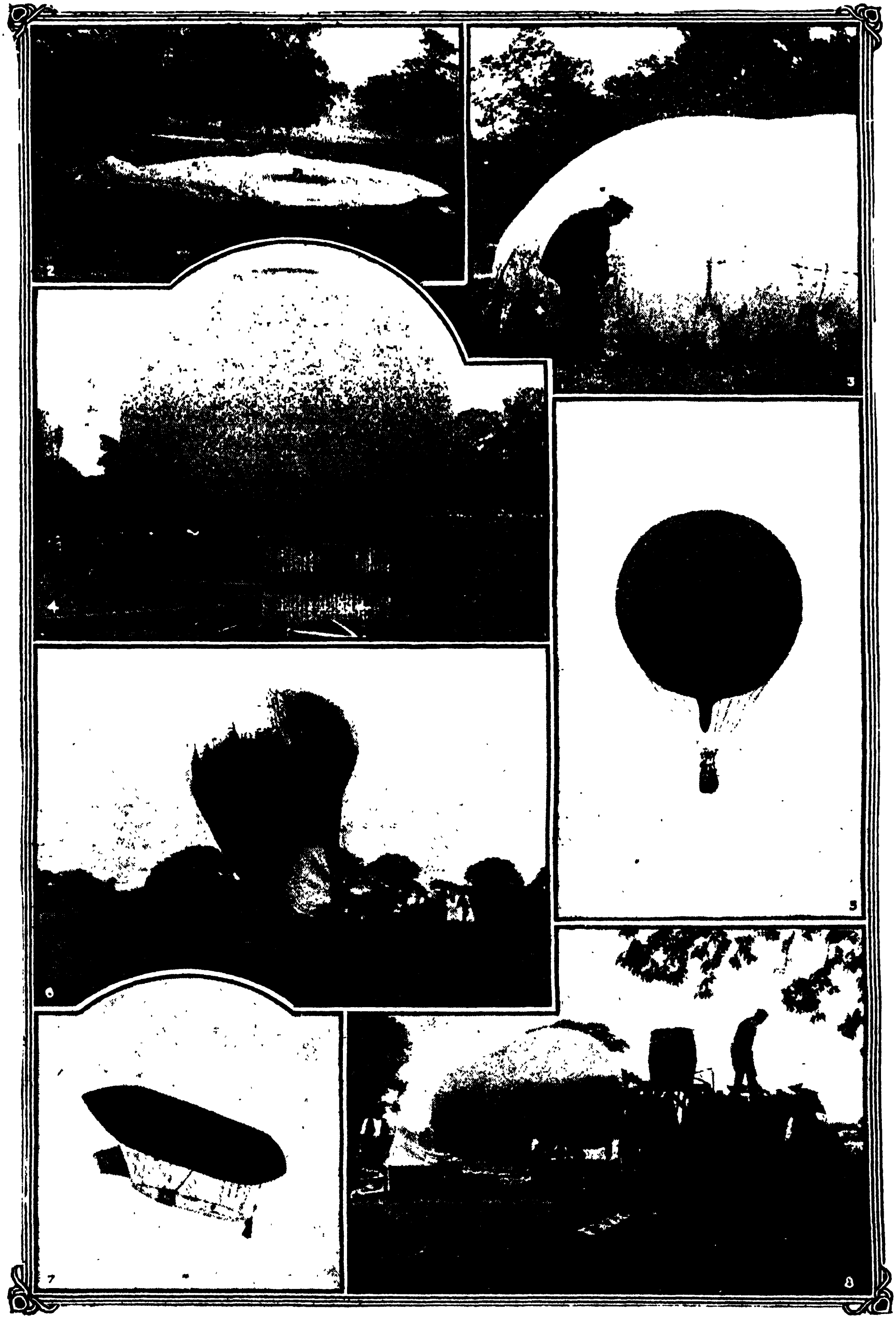
It is now desirable to remove two of the sandbags from each of the leading lines and allow an assistant to take his position in the hoop, then to remove further sandbags all round the balloon until the balloon begins to rise, and the bags get out of reach of the men. The assistant in the hoop then proceeds to unhook and lower the remaining bags until the lifting power of the gas causes the balloon to rise.

Entry of Passengers. At this period the individuals who are to ascend should take their positions in the car, after which more sandbags may be lowered from the leading lines. A number of sandbags containing fine sand should be placed in the car as well as all instruments and packages to be carried aloft. When the remaining sandbags are removed from the hoop, the lifting power of the balloon may be tested.

If the weather be calm, there is no difficulty about this; if windy, however, some trouble will be experienced. When the lifting power has been discovered, two or three extra sandbags may be placed in the car in order to compensate for the weight of the assistant in the hoop, who should now untie the mouth of the balloon, permit the valve line to drop to within reach of those in the car, and himself leave the hoop. The balloon may now be finally balanced and the lifting power arranged in accordance with the force of the wind. If calm, little lifting power will be required; but if windy, considerable margin of lifting power will be necessary to enable the balloon to rise rapidly and thus clear all obstacles on the earth.

Sensations in Ascending. There is no physical inconvenience, and nothing but the sense of sight to tell the passengers that they are moving. The balloon has now become, as it were, a part of the atmosphere [5], and moves onward with it, in a perfect calm. The aneroid barometer which is carried forms the only sure means of telling the height. It will be observed to fall rapidly as the altitude increases. Generally within half an hour of the start the maximum altitude will be attained, and at an altitude of perhaps 2,000 ft. the balloon first floats along at a uniform altitude for a certain time, and then commences to descend slowly. Having once commenced its descent, owing to the overflow of gas it will continue on its downward course unless checked by the discharge of ballast. The usual procedure is to discharge the ballast in small quantities when the balloon has attained its maximum altitude so that it may continue a more or less horizontal course at this height.

The Descent. The balloon continues to ascend and descend, ascending with the discharge of ballast, and descending with the natural overflow of the gas through the open mouth or safety valve. Eventually comes the time to look ahead and decide on the place to descend. If calm, any open field may be selected; if windy, however, great care should be exercised, and the descent preferably made after passing over a town rather than before reaching it. If windy, a sheltered spot should be aimed at; this may best be secured by waiting until hills have been passed, and then descending in the valley. Before permitting the descent to take place, the trail rope should be paid out to its full length; it will now hang from the hoop, to which it is secured, and descend downwards its full length of 300 ft. The grapnel rope, too, should be released from the edge of the car, and, being also fixed to the hoop, will hang pendant, but as the grapnel itself still remains on the edge of the car, it hangs doubled for half of its full length. It should not be omitted to secure the neck line to the cross rope on the hoop, leaving a yard or so slack rather than fixing it taut, so as to give the fabric of the balloon a little play. As the balloon descends preparatory to the landing, the trail rope will be the first to touch the ground, and the speed of the wind will be easily noticed by



AERIAL NAVIGATION

2. Balloon spread ready for filling 3. Lowering the sandbags during inflation 4. Inflation nearing completion 5. Balloon sailing in mid-air 6. Descent of a balloon 7. The Spencer airship in mid-air 8. Filling airship with hydrogen

the rate at which this rope is drawn across the country. If the balloon descend gradually, and with not too great a momentum—conditions which should be assured by small discharges of ballast if necessary—when about half of the trail rope is on the ground the balloon will no longer continue to descend, the loss of the weight of that portion of the rope which trails on the ground causing the balloon again to have an upward tendency. This has the effect of maintaining the balloon at a convenient height for watching the fields over which the balloon is passing.

Touching Earth. When a suitable landing field is observed, the valve line may be pulled, and sufficient gas released to bring the balloon to earth. Immediately on touching the earth the valve should be opened fully. If the speed across the field seem to demand it, and the weight of the passengers in the car does not stop the onward course of the balloon, the grapnel may be released, but not until the valve has been kept open as long as possible. To throw the grapnel too soon will give the balloon an upward lift, and produce unpleasant jerks, as the grapnel is ineffectively jerked over the land, but if it be not thrown until sufficient gas has escaped, the lifting power of which will be equivalent to its weight, then, when it is thrown overboard, the balloon and basket will continue to remain on the ground, moving along at the ground level and giving the grapnel its best opportunity of doing its work. On no consideration should any of the occupants of the car be permitted to alight until the bulk of the gas has left the balloon. By this time quite a number of local inhabitants will generally have arrived [6], and there will be no difficulty in enlisting their assistance. The balloon, when nearing emptiness, can have its valve-spring removed, so that the doors remain open without the valve line being pulled for the completion of the deflation. Conveyances by this time will have been requisitioned, the hoop and car untoggled from the net, and the balloon and its net folded up and placed in its linen wrapper, thus forming one package, while the remaining impedimenta may be conveniently placed in the car, thereby forming a second package to complete the luggage.

Scientific Ballooning. A large number of ascents are made for purely recreative purposes. Scientific work, however, can well be undertaken in connection with balloon ascents. The usual scientific observations made in a balloon consist of (1) the altitude attained, which is deduced from the height of the mercury in a barometer calculated with regard to the temperature at the time; (2) the temperature, which is observed, and recorded by means of the thermometer; and, finally, (3) the percentage of moisture in the air, observed by means of the hygrometer, which is generally in the form of a wet and dry bulb thermometer. The mercury barometer is invariably replaced by the portable aneroid in all except scientific ascents. In the latter it is generally carried, and its readings compared with the column of mercury. An exceedingly useful combination is the registering baro-thermo-hygro-meter, which indicates the height, the temperature, and the dampness of the air by tracing three blue lines in ink on a revolving chart.

Electrical work is also carried out, an electroscope being carried to determine the electrical condition of the atmosphere through which the balloon is passing. These experiments, however, generally have a negative result.

Glass containers, with the atmosphere exhausted, are sometimes taken up, and opened at the maximum altitude in order that the air which enters may be brought down and analysed as to its constituents. Scientists can see other uses, such as dust counters, microbe traps, ozone testers, and other means of observing phenomena which do not readily occur to those not acquainted with the latest developments of science.

The Parachute. The parachute consists of a circular-like shaped canopy of silk, cotton, or linen fabric some 30 ft. in diameter, to support the weight of an average man. Twenty or more lines are passed through its surface from the centre to the circumference and thence downwards to a length of 40 ft., where they are secured to a small wooden hoop 1 ft. in diameter with sword matting, a minature of that used with the balloon. These lines are fixed to the circumference of the parachute and again are spliced round a ring of rope in the centre at the top. This rope ring has a diameter of 8 in. to 1 ft., and to it also the fabric of the parachute is fastened, the superficial foot or so inside being left open. This construction is a convenient one, and the hole in the top of the parachute is held by some to assist in steadying it at its descent; but the actual advantage of this small aperture seems very doubtful, the question of a correct proportion between the length of the lines carrying the weight and the diameter of the supporting surface appearing much more likely to conduce to a steadying descent than any small aperture not exceeding a 600th part of the surface.

Round the edge of the parachute is sewn a stiffish cord, which has the effect of keeping the mouth of the parachute somewhat open in order to catch the first inrush of air when commencing the descent. A hoop of 3 ft. to 4 ft. in diameter, too, is also sometimes slung from the top to assist to this end.

Using the Parachute. When using the parachute for the purpose of giving a display of its powers, it is usual to attach the parachute to the balloon by means of a thin cotton cord with a breaking strain of 80 lb. The fabric of the parachute itself weighs about 30 lb., so that it is well supported by this cord. The parachutist who is about to descend takes his position under the balloon holding the hoop of the parachute in his hand. Attached to this hoop is a swing-like cord in which he places his leg, and at the correct moment, when the altitude is sufficient and when the country beneath affords a suitable landing, he drops from the balloon.

When his weight is added to that of the parachute, the cord which supports it instantly breaks and the parachute and aeronaut commence the downward drop, the balloon in the meantime rapidly ascending. As the parachutist continues to gain speed the uprushing air enters the folds of the parachute and shortly the whole canopy is extended to its full size, and the downward drop is checked sufficiently to make the further descent safe and even pleasant. The slight oscillations of the parachute which sometimes occur give a wave-like sensation to the person who experiences it as if he were a bird with outstretched wings floating earthwards. The motions are vertical with the descent and horizontal in the direction and at the speed of the wind. The earth is reached at about the speed of 500 ft. per minute and the landing takes place with not much more force than alighting from a moving vehicle. If it were a passenger balloon from which the parachutist leapt, those remaining in the car would, of course, attend to the subsequent descent of the balloon. When the balloon is a special parachuting one it is arranged with a weight at the top and with a somewhat large aperture at the bottom. After the parachute and the aeronaut have left, the weight at the top naturally turns it upside down. The gas escapes through the large open mouth, and, devoid of its gas, the erstwhile balloon becomes a piece of falling material which speedily reaches the earth, a vehicle being sent to recover it.

Hot-air Balloons. When there is difficulty in obtaining a supply of coal gas for ballooning purposes and the great cost of hydrogen renders it impracticable, the hot-air balloon is adopted. For practical purposes one of 60,000 to 80,000 cubic ft. is used. It is of 60 ft. diameter and has a height of about 70 ft. It is constructed of a strong cotton fabric, and as the net would be both heavy and troublesome it is dispensed with, and in its place strengthening webbing bands are sewn on to the surface of the balloon. The mouth is some 12 ft. in diameter, and coming from that are four lines which carry the weight. No varnish is used on the outside, but the inside is covered with a distemper paint in order to render it airproof and to prevent its fabric from being scorched. This style of balloon is mostly used for parachute descents.

To inflate the hot-air balloon a 30 ft. trench 4 ft. wide and 4 ft. deep is dug in the ground. This is covered up with iron plates so as to make it into a tunnel. A portion at each end is left open—at one end to light a fire of wood and at the other end to receive a chimney 5 ft. high, most satisfactorily built of bricks. The balloon itself is suspended over this chimney by means of a rope passing over two pulley blocks attached to poles about 35 ft. high. These poles are securely stayed with ropes to the ground so that the weight of the balloon hanging on the rope stretched between them will be supported.

Filling with Hot Air. The balloon, having been drawn over the chimney, is carefully spread out in circular form so that it has the appearance of a large bell tent, having its apex at the horizontal rope and its base (about 50 ft. in diameter) occupying the space between the two poles, the chimney being in the interior.

A large number of persons are stationed round the balloon and hold on to the fabric. The fire is then lighted and maintained at a moderate heat until the rush of warmed air along the chimney causes the balloon to rise. The bell-tent-like appearance now gives way to a semispherical appearance and the strain from the supporting rope is taken off. As the balloon is filled the people round it permit it to rise higher and higher. When the inflation is nearing completion the parachute is attached to the lines from the mouth and the parachutist holds himself in readiness for the ascent. The suspending rope is now drawn through the pulley blocks and away from the top of the balloon, the pole to the windward is lowered, and the balloon finally inflated.

At this period the fire at the entrance to the tunnel is raised to its maximum and the heat within the balloon thereby increased. In order to prevent a premature departure, four stakes having rings on them are securely fixed in the ground, round the chimney, and through these rings extra ropes from the mouth of the balloon are passed so as to form efficient means of holding the balloon in addition to the persons who are holding the fabric itself.

These ropes may be held to a single point and fixed to a liberator by which they may be simultaneously released, or they may be entrusted to four assistants who can release them at the word of command. From fifteen to twenty minutes is all the time that is needed after once the fire is lighted.

The Ascent. When sufficient lifting power has been obtained the aeronaut from his position at the sling at the end of the parachute gives the word to let go and the balloon then rises, sluggishly at first, but gaining momentum every moment.

The aeronaut ascends with this hot-air balloon to the desired height, and then pulls the cord attached to the liberating trigger and descends in the same manner as described with the gas balloon, the hot-air balloon being weighted and arranged to turn over and empty itself also in the same manner.

Captive Balloons. For military purposes and for out-door entertainments captive balloons are employed. In calm weather, a balloon may be held by means of a rope, and permitted to ascend to some 1,000 ft. or so in height, where it will remain in position and enable those in the car to obtain more or less extensive views according to the condition of the air. From a height of 1,000 ft. a distance of practically twenty miles may be seen, and as the view extends all round to the horizon, this means an area of some 1,200 square miles. Naturally this fact renders the use of the captive balloon of eminent service for reconnoitring for military purposes, and forms the system of military ballooning adopted by our authorities. For purposes of amusement, a large balloon, capable of carrying from six to twelve

persons, is generally used. It is similar in construction to the ordinary passenger balloon, with such modifications only as the particular requirements need.

It is fitted with additional network, known as the *equatorial lines*, which encircle the balloon so that they may be used as stays to hold the balloon steady by being attached to rings fixed on the ground. The car is a circular gallery construction, with a door to permit easy entrance.

The "Captive" Equipment. The captive rope of steel wire or hemp passes through a large circular aperture through this car, and thence over a pulley block having universal movement, firmly secured to an anchor in the ground. It then passes horizontally along the surface, or through a tunnel slightly beneath the surface of the earth, for some 200 ft., where a winding engine, fitted with a drum for its reception, is placed. This engine, which is usually of about 8-h.p., serves to pay the rope out at the ascent, and haul it in at the descent, until the car has reached the earth. Captive ascents are possible only in a moderately tranquil state of the air, but experience shows that in most places a very fair percentage of days during the summer season are practicable for actual working.

Captive ballooning for military purposes is conducted on a much smaller scale. A standard size of balloon is 10,000 cubic ft. capacity, capable of carrying two aeronauts to a suitable height for observations. It is always inflated with hydrogen gas, which is carried compressed in tubes to the site of the ascent.

Airships. In a balloon, we are able to start when we like, to ascend higher or lower, and by means of the valve to drop to earth at any moment we desire; but we cannot decide beforehand the direction in which we shall proceed on any given day. An airship, with a speed of 15 miles per hour, will move at the rate of 25 miles per hour with a 10-mile breeze, but at only 5 miles per hour in a contrary direction. There are two classes of airships—the flying machine, which rises in the air purely by mechanism, and the navigable balloon. The problem of both is to propel themselves through the air, and the real question, therefore, is simply which can go at the greater speed. The answer to this question may eventually be the flying machine, but the great objection at the present moment is its want of stability in the air. Hitherto, the only successful journeys through the air have been made by the propelled balloon.

The Spencer Airship. In the most successful airship [7] ever used in Great Britain, and frequently navigated by the brother of the writer, the buoyancy vessel consists of an elongated balloon of fusiform shape, which is inflated with hydrogen gas [8], and has a capacity of 30,000 cubic ft.—the gas having a lifting power of 2,100 lb. This is necessary to carry the weight of the entire structure. The balloon portion is made of closely woven fabric, varnished several times inside and outside, to render it impervious to hydrogen gas. Running horizontally round it is a sailcloth band securely stitched on, the fabric being doubled and festooned for some distance up all round this band in order to give greater strength. The cordage is all attached to this band, passing through eyelets made within it, and hanging downwards to support the framework with all its mechanism. This buoyancy vessel has a valve in the upper part to release the gas when desired, and in its lower part an automatic valve which relieves any undue pressure before the bursting point of the fabric is reached. The framework or keel, which is a triangular-braced construction of bamboo, measures 50 ft. long, and hangs 12 ft. below the gas vessel. It carries in front a screw propeller or tractor of 12 ft. diameter on a steel shaft, which is supported by ball bearings and runs through gear wheels and a clutch to the motor.

Propelling Mechanism. The petrol motor is situated centrally in the framework, and one feature of its construction is that its exhaust-box is covered with wire gauze, on the Davy safety lamp principle, to guard against ignition should any gas approach it. Its fuel of petrol is carried in a brass container, connected with copper tubes, and a similar cylinder holds the water which circulates over the cylinder for cooling purposes. The car in which the aeronauts take their place is situated in the rear portion of the framework, and the mechanism of the motor is controlled by Bowden wires. Further to the rear is the rudder with two ropes leading to the car. A balance or trail rope hangs downwards from this framework, held by two points at the front and back so that its position may be changed so as to take its weight to the front or rear as desired, and thus alter the angle of the whole airship to the horizontal, as it is desired to point it upwards or downwards. At present there are two of these aerial craft in the balloon hall at Highbury ready for flights at short notice. One is of small horse-power, capable of travelling through the air at the rate of 10 miles per hour, and one of 24-h.p., capable of being driven at speeds of from 20 to 25 miles per hour.

To attain proficiency with these airships continued flights are necessary. When one first enters the water he cannot swim; when a cycle has been obtained, it cannot be ridden without learning, and so it is with the airship—success comes by continual practice.

Naturally these experiments are expensive, and the amount of use to which these airships are put, therefore, depends upon the support and interest which are secured.

Vehicle Construction concluded

DOES THE HOUR BRING THE MAN?

True and False History. The Glorified Gossip of Courts and Kings. The Love of Personalities. Where do Great Men Come From? Man and His Environment

Continued from page 3872

By Dr. C. W. SALEEBY

FOR long years history has been taught in our schools and in the schools of all nations. The reader may or may not have been fortunate enough to escape the common, vulgar, and futile conception of history. This conception has been briefly epitomised by Herbert Spencer as "a record of royal misdemeanours," and since he is primarily responsible for the new conception of history, we may add to this phrase of his an amusing but deeply significant quotation from his Autobiography (II., 83). "I have a vague recollection of amusing Professor Youmans by my response to some remark or question coming from our guide at Holyrood—'I am happy to say I don't know.' Probably the remark or question referred to Queen Mary. On this, as on kindred occasions, I thus implied my satisfaction, partly in having used time and brain-space for knowledge better worth having, and partly in expressing my small respect for gossip about people of no intrinsic worth, whether dead or living." Elsewhere he refers to "those who look into the records of the past, not to revel in narratives of battles or to gloat over Court scandals, but to find how institutions and laws have arisen and how they have worked." Again, in the same wonderful book, Spencer's famous "Study of Sociology," which we shall afterwards discuss most carefully, we find a passage which, after our discussion of the book, the reader will surely study in full for himself.

What is True "History?" Speaking of sociology, Spencer says ironically, with reference to people who have the conventional notion of history:

"Of course, it is not to be put on the same level with those historical studies so deeply interesting to them. The supreme value of knowledge respecting the genealogies of kings, and the fates of dynasties, and the quarrels of Courts, is beyond question. Whether or not the plot for the murder of Amy Robsart was contrived by Leicester himself, with Queen Elizabeth as an accomplice, and whether or not the account of the Gowrie Conspiracy as given by King James was true, are obviously doubts to be decided before there can be formed any rational conclusions respecting the development of our political institutions. That Friedrich I. of Prussia quarrelled with his stepmother, suspected her of trying to poison him, fled to his aunt, and when he succeeded to the Electorate intrigued and bribed to obtain his kingship; that half an hour after his death his son Friedrich Wilhelm gave his courtiers notice to quit, commenced forthwith to economise his revenues, made it his great object to recruit and drill his army, and presently began to hate and bully his son—these, and facts like these about all Royal families in all ages, are facts without which civilisation would obviously be incomprehensible. Nor can one dispense with full knowledge of events like those of Napoleon's wars—his Italian conquests and exactions, and perfidious treatment of Venice; his expedition to Egypt, successes and massacres there, failure at Acre, and eventual retreat; his various campaigns in Germany, Spain, Russia, etc., including accounts of his strategy, tactics, victories, defeats, slaughters; for how, in the absence of such information, is it possible to judge what institutions should be advocated, and what legislative changes should be opposed?"

The History of Societies. "Still," Spencer proceeds, "after due attention has been paid to these indispensable matters, a little time might perhaps with advantage be devoted to the natural history of societies. Some guidance for political conduct would possibly be reached by asking—What is the normal course of social evolution, and how will it be affected by this or that policy? It may turn out that legislative action of no kind can be taken that is not either in agreement with, or at variance with, the processes of national growth and development as naturally going on; and that its desirableness is to be judged by its ultimate standard rather than by proximate standards."

These quotations will suffice to show what we mean by speaking of a new conception of history. What study can be named greater than the record of man? Yet do we not all know that, owing largely to the exceeding difficulty of teaching any real history, and to the examination system, and to the fewness of those who "seek the wider meanings of facts," history is too often concerned with the dates of battles, with the contemptible *amours* of men who are only the more contemptible because they were called kings—since, as Carlyle said, "the only divine right of kings is the right to be kingly men,"—and with such-like trivialities. It is time, then, that we who seek to make the best use of our intelligence should distinguish once and for all between that notion of history which regards it as merely a—more or less—glorified gossip, amusing but meaningless, delectable but despicable, and that conception of history which sees in it the record of the life of man or that mighty *Organism* which was Comte's conception of humanity, and which, to his mind, was no less than an object of worship.

Judge a Man by his Talk. You may estimate the intellect of a man, says Herbert Spencer, by observing the proportion of generalities to personalities in his conversation. Have we not all heard with our ears that "he" or "she"—according as whether the

speaker be woman or man—is the main topic of conversation in the street; and do we not know that the person who does not dearly love a piece of gossip is scarce almost to vanishing point? The novel, the short story, the drama, and an enormous proportion of conversation among great and small, young and old, are concerned with what this or that person did, does, or is going to do. The teller of stories has been appreciated in all generations and in all ages of each generation. He is a power in the savage tribe.

The Universal Love of Personalities. We who believe in the theory that the history of the individual is a recapitulation of the history of the race may note the significance of the fact that children love stories, that savages do so likewise, and that people of scant intelligence prostitute their powers of reading almost entirely to this end. "But when are you going to write a book?" was the cruel question which Carlyle asked William Black, the well-known novelist. The love of personalities, in short, is universal in its distribution and its influence. Hence it is that the death of one king or another from eating too many lampreys is a historical fact as history is at present conceived. There is before the present writer at this moment the page of a child's instructor which nurtured his seven-year-old mind, and contains, in sequence, the portraits of the kings of England, with their names and the chief fact about each beneath the name. Here he finds, what his mind has retained for so many years, the following: "Henry I. Beauclerc. Died from eating too many lampreys." True it is that a magnificent lesson might have been taught even to a child from this fact, there being no facts, not even this, in all the universe, which are insignificant to the philosophic mind; but to the mind of the historian the fact was an end in itself. It was "history."

Persons and Things. The same love of personalities holds in politics, so that a politician may go about, let us say, proving himself ignorant of the first principles of his subject, and incapable of reasoning upon what he is under the delusion of thinking to be *data*, yet a certain number of people will follow him and "wonder with a foolish face of praise" because the love of his personality draws them on. Elsewhere the present writer has called the love of personalities the mainspring of fiction, and, except for the very few, it has hitherto been the mainspring of "history," which is mostly fiction. Most of us prefer talking about people to talking about things, and reading about people to reading about anything else that words can express. True it is that the proper study of mankind is man, as Pope said, and that if we analyse the love of personalities and try to recognise the element of sympathy, for instance, that may be found in it, we shall see in it not a thing to be sneered at or a thing that we may one day expect to overcome. As a matter of fact one cannot conceive of society as existing without it, for it is an inevitable concomitant of that sympathy and community of interest without which societies are impossible. And who shall pass a verdict on the desirability of a mental trait—this love of or interest in personalities—which may show itself in the abominable tittle-tattle of a smoking-room or boudoir, and yet is essentially one and the same with the force that impelled the observant genius of Shakespeare to depict a Iago or a Hamlet?

Descriptive Sociology. We are about to observe that there are two distinct theories of causation in history, and in so doing we shall note how the love of personalities may be made useful. The term *descriptive sociology* was coined by Herbert Spencer to describe a great book upon which he spent many thousands of pounds and which he was finally compelled to abandon, but which is now to be completed by means of the money which he left. He destined such a book for the day "when the love for the personalities of history is less and the desire for its instructive facts greater." The study which now goes by this name consists of "the collection and organisation of facts presented by societies of different types, past and present," since, in order to arrive at the principles of sociology there are required, "as bases of induction, large accumulations of data, fitly arranged for comparison." "These facts supply the student of social science with data, standing towards his conclusions in a relation like that in which accounts of the structures and functions of different types of animals stand to the conclusions of the biologist. Until there had been such systematic descriptions of different kinds of organisms as made it possible to compare the connections and forms and actions and modes of origin of their parts, the Science of Life could make no progress. And in like manner, before there can be reached in sociology generalisations having a certainty making them worthy to be called scientific there must be definite accounts of the institutions and actions of societies of various types, and in various stages of evolution, so arranged as to furnish the means of readily ascertaining what social phenomena are habitually associated."

Aristotle the Pioneer. It is very interesting to note that neither the conception nor its execution is new. Though Spencer was unaware of the fact, his mighty predecessor, Aristotle—whose intellectual resemblances to him in breadth of knowledge, magnificence of generalisation, and even in method, have been so often commented upon—conceived and carried out an essentially identical plan. The work which the great Greek called the *Politeiai* contained a descriptive history of the constitutions, manners and usages of 158 states. It would hardly be necessary to insist upon the immeasurable difference which time has wrought in the execution of the two enterprises. While Aristotle's horizon was only a few miles away, the later "Descriptive Sociology" discusses the English, Mexicans and other aboriginal New World races, the lowest races, such as Fuegians, Tasmanians, and Sandwich Islanders, the African races, the Asiatic races (excluding

the yellow peoples), the races of Northern America, the Hebrews and Phœnicians, and the French; while there are now in preparation parallel accounts of the Chinese, the ancient Egyptians, and the Greeks.

Here, then, we see a conception of history which has only to be described for its importance and truth to be recognised, but of which the unbiassed sociologist must ask, "Is it the whole truth?" Unquestionably a true conception of history must include a descriptive sociology, perhaps the most striking indication of the character of which, and the most remarkable comment on its claim to be ranked as history, is furnished by the fact that the names of individuals have no place worth mentioning in it and are scarcely to be encountered at all.

Causation in History. And here we encounter a fascinating question which we shall have no further opportunity of discussing in this course, since we cannot possibly return to what is now often called the *philosophy of history*, which we shall discuss now. With very rare exceptions, one of which we must at least note, all history that called itself and was recognised as history until Spencer's time dealt with individuals as all-important and with circumstances or environment as secondary, subsidiary, and only in quite negligible degree as causes of the actions of great men whom the historian celebrated. In the beginning of his "Study of Sociology" Spencer discusses what he there calls the *great-man theory* of history. In so doing he makes an allusion to the doctrines of that mighty literary genius and mighty soul Thomas Carlyle, whose inherent energy and power of language and personal conviction persuaded Ruskin to call him "the greatest historian since Tacitus." The work of Carlyle we may take as typical of, and as representing in its highest form, the great-man theory of history. This theory is as old as history itself and reached its finest flower in its last hours—or, rather, in its last hours as the whole truth. It is incredible that the reader has not read Carlyle's "Lectures on Heroes, Hero-Worship, and the Heroic in History." If he has not done so we must apply to him the words of Prospero: he is one of those "that have more time for vainer hours."

The Great-man Theory. In a few words from the first page we may describe the fundamental conception of that great book:

"We have undertaken to discourse here, for a little, on Great Men, their manner of appearance in our world's business, how they have shaped themselves in the world's history, what ideas men formed of them, what work they did. Too evidently this is a large topic. Indeed, an illimitable one; wide as Universal History itself. For, as I take it, Universal History, the history of what man has accomplished in this world, is, at bottom, the History of the Great Men who have worked here. They were the leaders of men, these great ones; the modellers, patterns, and in a wide sense creators, of whatsoever the general mass of men contrived to do or to attain; all things that we see standing accomplished in the world are properly the outer material result, the practical realisation and embodiment, of Thoughts that dwelt in the Great Men sent into the world; the soul of the whole world's history, it may justly be considered, were the history of these."

This is a splendid passage, and it seems to bear in its forehead the stamp of truth; but here we are trying to be scientific, and we must not permit ourselves to confound splendour as such with truth as such. We may remember Huxley's description of rhetoric: "that pestilent cosmetic with which men varnish the fair face of truth." Is this great-man theory of history *true?*

The Kings of Thought. Now, it is all-important that we be fair and unprejudiced in our study of this great question. The present writer clearly has a bias in favour of Spencer, who, as we shall see, opposed the great-man theory; but, on the other hand, he can refer the reader to many previous parts of the SELF-EDUCATOR in proof of the assertion that he is also a hero-worshipper, who never loses an opportunity of quoting the lines of Shelley:

"And he is gathered to the kings of thought
Who waged contention with their time's decay
And of the past are all that cannot pass away."

Or these lines of Wordsworth:

"There is
One great society alone on earth
The noble Living and the noble Dead."

Or, greater still, this from Daniel:

"They that be wise shall shine as the brightness of the firmament, and they that turn many to righteousness as the stars for ever and ever."

We make the claim, then, that we are unprejudiced. But this is not an instructor, but a self-educator, and the reader will listen to no claim as final, but will decide for himself.

Spencer, and, following him, sociologists in general, urgently oppose the great-man theory of history. Spencer traces the genesis of it to the customs of savage life, where the great topic on a return from the warpath is always the doings of some chief or warrior. Such narratives, perhaps accompanied by a dance or a chant, constitute the whole history or chronicles of savage tribes. Similarly, the famous Moabite stone, the Egyptian frescoes, and the Greek epics follow the injunction to "praise famous men." The power of this theory is strengthened by the early upbringing of each of us. "Arms and the man" form the end of the story, as they form its beginning. The reader will remember the first words of the first line of Virgil's great poem, "Arma virumque cano" (Arms and the man, I sing). Hence, says Spencer, "you find but a scattered few likely to take anything more than a biographical view of human affairs."

The Genesis of Great Men. The valid and conclusive criticism on this view is that we are entitled to ask, Whence comes the great man? If we abandon, as we must abandon nowadays, the doctrine which has had its place

in the history of every society, that the origin of the great man is supernatural, "then the origin of the great man is natural; and immediately this is recognised, he must be classed with all other phenomena in the society that gave him birth, as a product of its antecedents Along with the whole generation of which he forms a minute part, along with its institutions, language, knowledge, manners, and its multitudinous arts. and appliances, he is a resultant of an enormous aggregate of forces that have been co-operating for ages. . . . The genesis of the great man depends on the long series of complex influences which has produced the race in which he appears and the social state into which that race has slowly grown. If it be a fact that the great man may modify his nation in its structure and actions, it is also a fact that there must have been those antecedent modifications constituting national progress before he could be evolved."

The Truth Between Two Extremes. In a very early society, according to Spencer, the great-man theory "approximately expresses the fact in representing the capable leader as all important." But "just as fast as war ceases to be the business of the whole male population, so fast do societies begin to develop, to show traces of functions and structures not before possible, to acquire increasing complexity along with increasing size, to give origin to new institutions, new activities, new ideas, sentiments, and habits—all of which unobtrusively make their appearance without the thought of any king or legislator. And if you wish to understand these phenomena of social evolution, you will not do it, though you should read yourself blind over the biographies of all the great rulers on record down to Frederick the Greedy and Napoleon the Treacherous"

Let us consider whether now, after thirty years, we can pronounce any judgment upon this quarrel between Spencer and the historians. It seems to the present writer—who expresses his views merely as subject matter for thought, and all of whose ends will be defeated if the reader accepts anything whatever simply because he says so—that the truth lies somewhere between the two extremes.

Destruction of Pre-Scientific History. Spencer overstated his case, as he was almost bound to do in the circumstances He has achieved the final destruction of what we may call pre-scientific history, and that is indeed well. But many of his critics have pointed out with force and justice that history cannot be made comprehensible—no, not even the history of the most advanced races—on any view which reduces the importance of the hero, or great man, to the Spencerian estimate. Truth is many-sided, and we all tend to see the side that is nearest us—whether owing to our training, temperament, or bias—to the exclusion of the other sides But it is the business of the philosopher to act, as Spencer himself urges, in another and higher connection: "In proportion as we love truth more and victory less, we shall become anxious to know what it is which leads our opponents to think as they do. We shall begin to suspect that the pertinacity of belief exhibited by them must result from a perception of something we have not perceived. And we shall aim to supplement the portion of truth we have found with the portion found by them." And the common view *does* represent a portion of truth. No one will question that the history of the world is other than it would have been had Napoleon or Cæsar or Moses not lived. It is true that these men were the products of their environment; but it is far truer to say that, though they were conditioned by their environment, and would not have been what they were in other environments, yet their environment does *not* give an adequate account of their causation.

The Hour and the Man. No better instance of the truth which we are trying to recognise can be found than in the case of great crises in society, whether political, or religious, or other. The truth of the Spencerian theory is recognised—and exaggerated—by those who say, with too little qualification, that the crisis always produces the man, that when an evil system has reached a certain point the social environment invariably causes the evolution of the necessary individual, instances of whom we may find, according to our beliefs, in Martin Luther, or John Wesley, or Savonarola, or in any of the leaders who have freed an oppressed people. But, in point of fact, this generalisation, which implies that the great-man theory is entirely untrue, is itself imperfectly true. Further study teaches us that, in point of fact, the tyranny, the abuse, the evil of whatever kind, has only too often continued long after it should, according to this theory, have produced the man necessary to end it. Sober history does not support the comfortable doctrine that, as soon as the circumstances urgently demand a great man, they produce him. On the contrary, time and again we find that the evil was no greater at the moment of its overthrow than it was a century before. In short, the hour was ripe but the necessary hero was not forthcoming. Thoughtful people, looking at the present state of Russia, believe themselves to see in that unhappy land such sociological phenomena as, according to the view which denies the great-man theory entirely, should long ago have produced the necessary man. They think, however, that not only has this man been wanting in the past, but he is wanting to-day. They believe that all the conditions are ready in Russia for the inauguration of a newer and better era, except one. The oppressed have not produced the all-essential hero.

Man's Relation to Environment. These things may or may not be so. We submit them to the reader's judgment. The proposition which we would have him consider and, if he can, accept, is that what we have called causation in history is twofold—that the doctrine which regards all influences save individuals as important is only a half-truth, and that the doctrine which regards no influences except the power of individuals as important is only another half-truth. In other words, the history of societies is determined neither by the inanimate and impersonal alone nor by the animate and personal alone, but

by the interaction of both ; just exactly as the history of an individual organism is determined, not alone by its inherited or innate characters, not alone by the environment in which it finds itself, but by the interaction of both. It seems to the present writer that opinion, having swung too far away from the older direction, may now be allowed to rest in the reasonable doctrine that in the making of history neither are external conditions naught nor are individuals naught. Both are essential, and neither can be ignored. And for ourselves we do not think it worth while even to enter into any argument as to which of these factors has been the more important. Let the reader consider and he will see that such an argument, if it went deep enough, would soon find itself to be meaningless. At any rate, we have here offered an introduction to the reader of that mighty study which is called the philosophy of history, which, he must take our word for it, is possessed of far greater dignity and interest than we are likely to have been able to suggest

A Landmark in the History of Thought. Here, certainly, is the place in which we may discuss and dismiss the relation of sociology to geography. We have already asserted that sociology is the synthesis and crown of all the sciences, an assertion of which we shall find support in every paragraph. But the relation of sociology to geography is of special significance because we must take it into conscious account in our conception of history, and also because it will ever be associated with the name of a great English historian. We often hear it said that a given race displays given characters—as, for instance, extreme conservatism and hatred of change, because of the hot and enervating character of the climate in which it lives ; or that the literature of a certain people displays a great intimacy with Nature because of the mountains, the valleys and the lakes among which the poets of that race have lived ; or that a superstitious element is conspicuous in the religion of a certain people because they are familiar with some of the most terrifying and awe-inspiring phenomena of Nature —thunder, tempests, earthquakes. We feel that there is a truth here, though it is much more difficult to estimate its measure, and there is a great classic in which this doctrine is expressed, with exaggeration no doubt, but still with extraordinary erudition and force that make it, within its limits, a landmark in the history of thought.

"The Secret of Europe." The fame of Buckle (1821-1862) depends upon the only work of his to which we need here refer—his "History of Civilisation in England." This book, of very great size, is really no more than an introduction to the complete work of which the author's premature death has deprived us. Perhaps the central doctrine of the work is the intimacy of the relation between geography and sociology, the doctrine "that climate, soil, food, and the aspects of Nature are primarily causes of intellectual progress—the first three indirectly through determining the accumulation and distribution of wealth, and the last by directly influencing the accumulation and distribution of thought, the imagination being stimulated and the understanding subdued when the phenomena of the external world are sublime and terrible, the understanding being emboldened and the imagination curbed when they are small and feeble" and, as a corollary, "that the great division between European and non-European civilisation turns on the fact that in Europe man is stronger than Nature, and that elsewhere Nature is stronger than Man, the consequence of which is that in Europe alone has man subdued Nature to his service." It is almost a necessary complement of these doctrines that "individual efforts are insignificant in the great mass of human affairs, and that great men, although they exist and must at present be looked upon as disturbing forces, are merely the creatures of the age to which they belong." In short, we may say that the theory of Buckle is a theory of physical fatalism—that human history might have been inferred from a knowledge of climate.

Many though his exaggerations are, Buckle undoubtedly enunciated great truths, and, notwithstanding many inaccuracies of detail such as, of course, no historian can free himself from, his book must be read to-day by any who would make a serious study of history. It has recently been published in the "World's Classics," so that it can be obtained for a very small sum.

The Greatest Study in the World. The reader must not infer from the space which we have occupied in discussing the new conception of history that sociology is no more than scientific history. If it were no more it would still be, perhaps, the greatest study in the world. Yet this is really only one of its parts. We have placed it in the forefront of our study because of its great importance, and because by means of history and geography we are able to show that sociology, though a science, is most intimately related to other studies which we do not customarily think of as sciences—though we certainly should do so. On the other hand, the present course has been designed to follow in a rational and educative sequence the courses on Biology and Psychology. It is upon these sciences that our science is essentially based, and it is from their side and not from the side of history that we seek to approach it. An American observer has said that only too many professors of sociology in the United States have just "happened into" the subject—that when a man is unfit, whether by training or intelligence, for anything else, he can, at least, take up sociology, just as teaching in former days was the last resort of the incompetent. On the contrary, it is difficult to say whether the study of sociology or the profession of teaching is the more difficult and demands the greater training and devotion and skill on the part of the aspirant. The men who "happen into" sociology are the men who make it a laughing-stock and a byword amongst serious people, and we must try to avoid anything so discreditable as their performances.

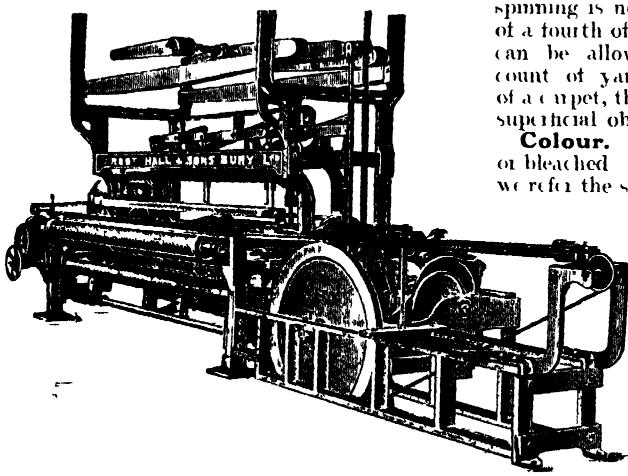
Continued

CARPET WEAVING

Selection of Carpet Yarns. Setting in Brussels and Wilton Carpets. Weaving Axminster. Patent Axminster. Tapestry and Velvet Pile Tapestry Carpets

By W. S. MURPHY

Carpet Wools. The carpet industry stands out so distinctly from the cloth weaving trades as to call for special study. In the weaving department most notably the particular differences are essential, not accidental. The carpet weaver uses a quality of yarns all his own. What are called *barbarian* wools serve the carpet manufacturer's purposes as well as, and in some cases better than, domestic wools. The wild sheep of India, Persia, and other quarters of the globe furnish wools of a hard, wiry character, which, utterly unsuitable for cloth manufacture, supply the hard strength and elasticity the carpet requires. We are far from asserting that fine, soft wools are not used in carpets, or that the finest wools would not make the finest carpets; but it must be kept in mind that we are producing for the market. Wild wools are cheaper, and give the desired results at less cost than common wools. Our supplies of wools are not always easy to trace, and the carpet manufacturer need hardly trouble whence the supply comes so long as it serves his purpose. East India, Persia, and Argentina are the main sources of carpet wools; from Oporto we gather a supply of wools for the best classes of carpets; and the coarser home breeds of sheep, with the skirtings and higher sorting numbers of the finer wools, make up the rest of our raw materials.



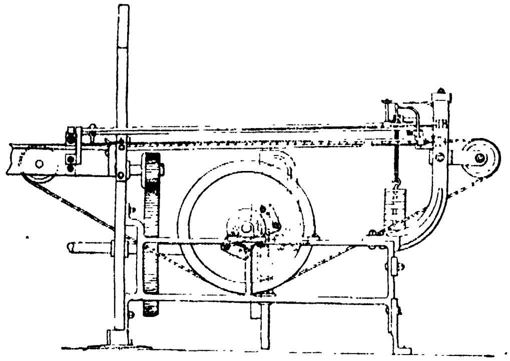
179 BRUSSELS LOOM

Yarns. Many carpet manufacturers buy their yarns ready made; but the greatest manufacturers carry through the whole process from beginning to end, from the fleece to the finished carpet. So far as the weaver is concerned, it matters little whether he gets his yarns from a hundred miles away or the adjoining room; he is concerned with the quality of his material. Uniformity and good colour are the primary requisites of carpet yarns. A good yarn is free from lumps and kemps, and is properly and regularly twisted throughout. The fault of lumpy and kempy yarn is obvious; but the unobservant weaver may not readily perceive why the uniformity of twist is so important. Carpets naturally show a good length of the yarn; if an irregularity of twist occurs, the surface of the carpet will show it, and no amount of treatment can hide the fault. The cut pile of the Wilton, for instance, will turn in every direction, like the grass blades in a badly-mown lawn. To make sure that the quality of the yarn is up to the standard, the weaver should test a sample hank by scouring it and comparing it with an unscoured hank; if the difference in twist and weight be very marked, the yarn should be rejected, or put into an inferior class of carpet. If a large quantity of one make of carpet is being woven, the tests should be repeated several times, because variations in quality are apt to occur. We do not in the least suggest fraud; it is merely a question of workmanship, and should be treated as such. In heavy yarns, such as are needed for carpets, exactness in spinning is not to be expected; but a variation of a fourth of a count is the utmost limit which can be allowed with safety. Uniformity in count of yarn adds much to the appearance of a carpet, though it may not seem likely to the superficial observer.

Colour. All carpet yarns are either dyed or bleached. For a knowledge of these processes we refer the student to the dyeing section of our course. But the weaver has an interest in the colouring of the carpet which cannot be passed over. To every weaving department one or more colourists are attached, whose duty it is to match the yarns. Selection of the colours is one of the most important functions in the making up of a carpet. Badly matched or unevenly coloured yarns would ruin the finest design conceivable. Each form of carpet has its own system of apportioning this work, and it may be better to study it in the course of each manufacture.

Warps. Carpets have two kinds of warp; the one is the *surface* or pile warp, with which is our chief concern, the other is the body or binding warp, which is composed of linen, cotton, or jute,

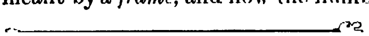
and in a few cases of wool. Linen is both warp and weft in the highest class of loop pile carpets; lately, strong cotton yarns have come into favour, because they are lighter and cheaper. The value of cotton as a carpet warp has not yet been thoroughly tested, and we do not undertake to dogmatise in comparing it with linen. Jute has gone greatly out of favour as a warp, because it does not stand well the hard wear to which carpets are subject. For



weft, or *shoot*, linen is almost universally used for all classes of carpets; it is softer and weaves better than cotton of the same weight and class. For tapestry carpets we use a warp significantly called *stuffing*, because it fills up the spaces between the threads of the warp. Stuffing is made of low-grade cotton yarns, or jute. It is very soft, and possesses very little tensile strength. Both warps and wefts are sized or dressed with strong size of a gluey nature, generally a weak gelatine.

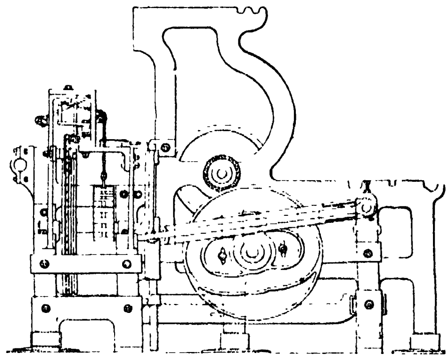
Having collected our various materials which are general to all forms of carpet, we must now proceed to examine the special constituents of each different kind. This may be done more simply and quickly in the actual process of manufacture than by any other method.

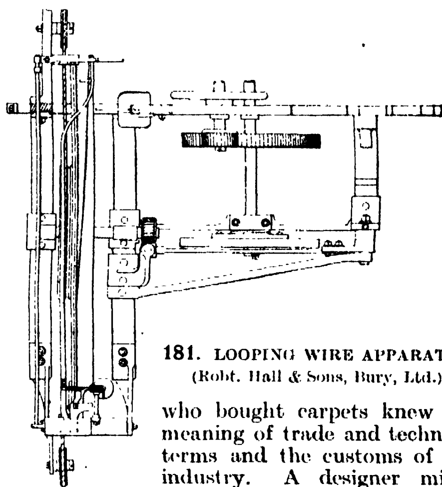
Brussels Carpets. According to trade theory, Brussels carpets are classed by the number of pile warps put into them. "Six-frame," "five-frame," "four-frame," and "three-frame," are the classes woven, the first being the heaviest and costliest, and not often sold on the market; "five-frame" is most in demand. In dealing with this part of our study, we must work warily, and make statements with due caution. First, let us understand clearly what is meant by a *frame*, and how the number of frames determines the class of the carpet.



180. LOOP-CUTTING KNIFE

Beginning to build up our pile warp, we lay down a creel of yarn bobbins, each one of which will supply a single thread to the warp. As there are 260 threads in the warp breadth, we require that number of bobbins. That is one frame. If the carpet is to be a five-frame—that is, a carpet with a pile five threads thick—we require other four creels or frames, each containing 260 threads or bobbins. According to the trade theory of former days, every frame contained yarn of a different colour, and a five-frame carpet was also a five-coloured carpet. Under this theory, any attempt to put more colours than frames into a carpet was regarded as a kind of fraud. It was said that manufacturers were cunning who made six colours appear in a five-frame, five colours appear in a four-frame, and so on. This was sheer and utter nonsense. Our good moralists supposed that the people





181. LOOPING WIRE APPARATUS (Robt. Hall & Sons, Bury, Ltd.)

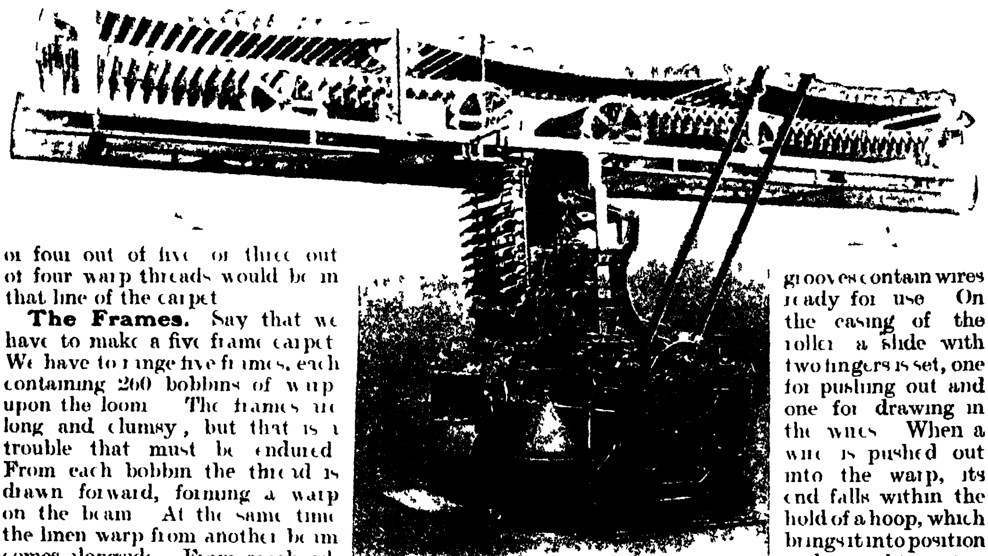
who bought carpets knew the meaning of trade and technical terms and the customs of the industry. A designer might put ten colours into a carpet, but no one would buy it because he supposed it contained ten frames of yarn. The buyer is more concerned in buying a carpet to get a pretty pattern and a reasonable bulk, or wearing quality, than with the adherence of the weaver to a trade tradition of which he has probably never heard. One way of thinning the pile warp, however, is resorted to which can hardly be regarded as altogether fair to the buyer. We can put in the required number of frames, but, instead of filling them with the 260 threads required, we may put in only two-thirds of the number and cover up the deficiency. There are various ways of doing this. Obviously, we may spread the impoverishment over the whole pile warp, or we can confine it to one or two frames. Even this, however, is not more heinous than the putting of a small number of warp threads into an ordinary cloth.

The Gammot. If the carpet is a five-frame with five colours, the duty of the "putter-on" is very simple. All he has to do is to procure the bobbins of the five different colours, put in the creels or frames, and his duty is ended. But when there are more colours than frames, and missing threads here and there, his position is one of more responsibility. From the design a plan of the warp called a *gammot* must be made out, and this is the guide of the putter-on. In the gammot are shown the threads which appear and those which do not appear in a given line of the warp. It is very simple. One line of squares on the paper is assigned to each frame, and there are 260 squares in each line. Where all the warp threads are to appear the whole of the squares will be coloured; where any thread is to be omitted, the square of that colour would be left blank. That is to say, five out of six, or four out of five, or three out of four warp threads would be in that line of the carpet.

The Frames. Say that we have to make a five-frame carpet. We have to range five frames, each containing 260 bobbins of warp upon the loom. The frames are long and clumsy, but that is a trouble that must be endured. From each bobbin the thread is drawn forward, forming a warp on the beam. At the same time the linen warp from another beam comes alongside. From overhead, the jacquard cords, the apparatus of which is already geared up, come down and each thread—say, 1,300 in all—is looped in its separate cord and passed through the dents of the reed.

Weaving the Carpet. The carpet loom is simply a large power loom [179] with an enormously heavy warp. We have studied the loom at considerable length, and can understand how it works. But the formation of the carpet pile is a feature which here demands full explanation. When studying design we acquired the general idea that all pile fabrics derive their special form from the insertion and binding into the warp of wires. The way in which this is accomplished is worthy of examination. A Brussels carpet looping wire is a thick knitting wire 27 in. long, and it is made to lie under the warp threads called to the surface by the jacquard cords. How to insert and withdraw those wires automatically was, for a long time, a serious problem. On some old looms still in use the first attempt at solving the problem may yet be seen. It consists of a reciprocating rod with a catch at the end, which hooks into one of a set of wires, and draws it into the shed. By a similar mechanism the wire is withdrawn, after other five have been put in and returned loose, the weaver placing it again in the groove, whence the rod can draw it out again and insert it into the shed.

Looping Wires. More common, however, and certainly more convenient, is the roller-wire mechanism which inserts and withdraws the wires automatically. Several methods of applying the principle have come into use, but all work on the same basis. A roller is grooved into six sections so that any one section will cover the space occupied by the number of wires inserted, and into those grooves the wires are inserted. The grooves contain wires ready for use. On the casing of the roller a slide with two fingers is set, one for pushing out and one for drawing in the wires. When a wire is pushed out into the warp, its end falls within the hold of a hoop, which brings it into position and straightens it in the warp. At the same moment the wire to be withdrawn comes into contact with the drawing out hook; it acts, and with the backward movement of the slide, is drawn into the groove of the roller. The roller performs one sixth of a revolution, and brings the next wire and the emptied groove into position. In this way we have always four wires in the fabric, while one is coming in and one is being withdrawn. An improved application of the principle, with apparatus much simplified, is shown in 181. On the front elevation we see the rope drum and pulleys which drive the mechanism; from the end elevation and plan, we can observe the connections between it and the whole loom.



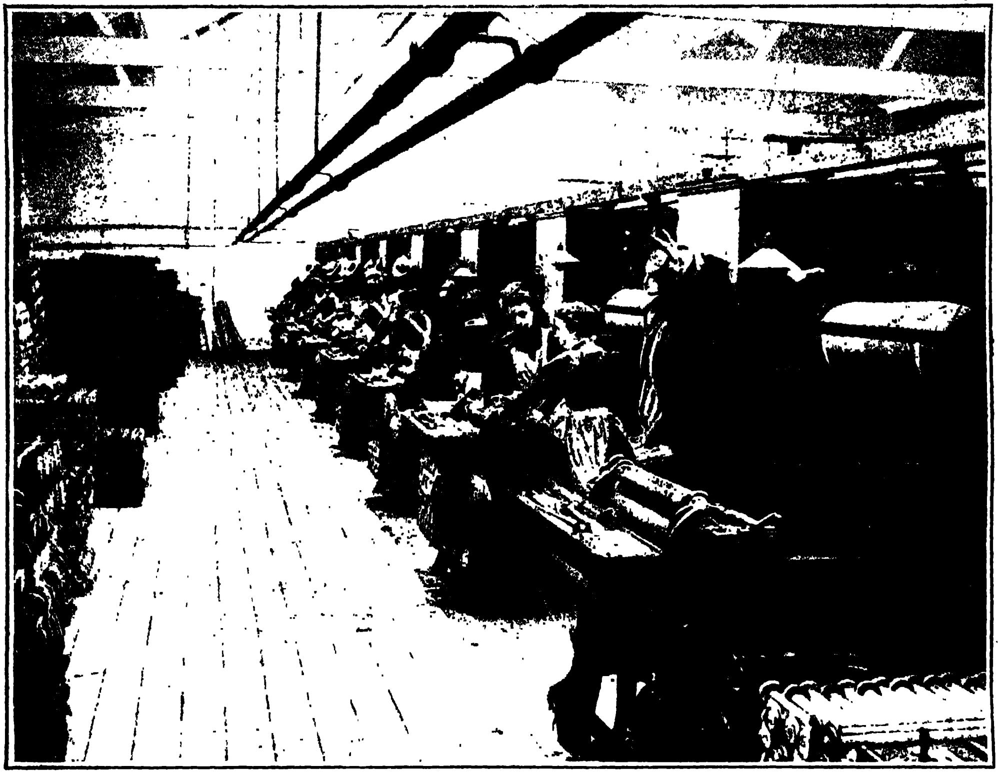
182. COMPTON LOOM
(R. Smith & Son, Kidderminster)

Order of Weaving. The weft shuttle is in the box and the loom is ready for starting. From the midst of the pile warp the jacquard selects the threads which are to form the surface at this

moment; the wire inserts itself under the raised threads; now the half of the linen warp comes up, and forms the shed; through this the shuttle darts with its thread of weft, binding the wire in; the pile warp goes down, and the linen warp crosses, leaving a shed through which the shuttle darts again. In this way we form the pile and build up the body of our carpet.

Wilton Carpet. Roughly speaking, the difference between the Wilton and the Brussels is that the pile of the former is cut to form a velvet pile, while the loops of the latter remain intact. But the technical differences are much greater than that. Wilton carpet looping wires are oval in form, standing higher and forming a larger loop than the round Brussels wires; and the extremity of each, as if the end had been hammered out and sharpened on the edge, is a knife blade [180], which, when the wire is withdrawn, cuts the loops. But the weaving of Wilton carpets differs in a very important particular from its rival fabric. On the Brussels, the picks of weft alternate, one up and one down; but in the Wilton weave there are two picks of weft up to one down, each wire having its own binding weft. This keeps the pile securely bound after it has been cut.

Axminster. The production of the older form of Axminster, which, in all but price, is the rival of the best Persian and Turkish carpets, belongs to a class of artistic handicrafts which, for various reasons, can hardly flourish in this country. No very considerable number of British artisans can ever be employed in that branch of the carpet industry, and those who may be, must be specially trained in all the practical details, from the first operation to the last, unless, indeed, they are mere labourers to the skilled workers. The essential characteristic of the Axminster and all the Oriental carpets is the knotting of the worsted pile, tuft by tuft, into the body of the fabric, involving hand labour of a tedious nature. This fact not only brings the cost of the carpet up to a figure prohibitive to all but the very wealthy, but it also gives the Easterns, with their cheaper standard of living, a great advantage over us.



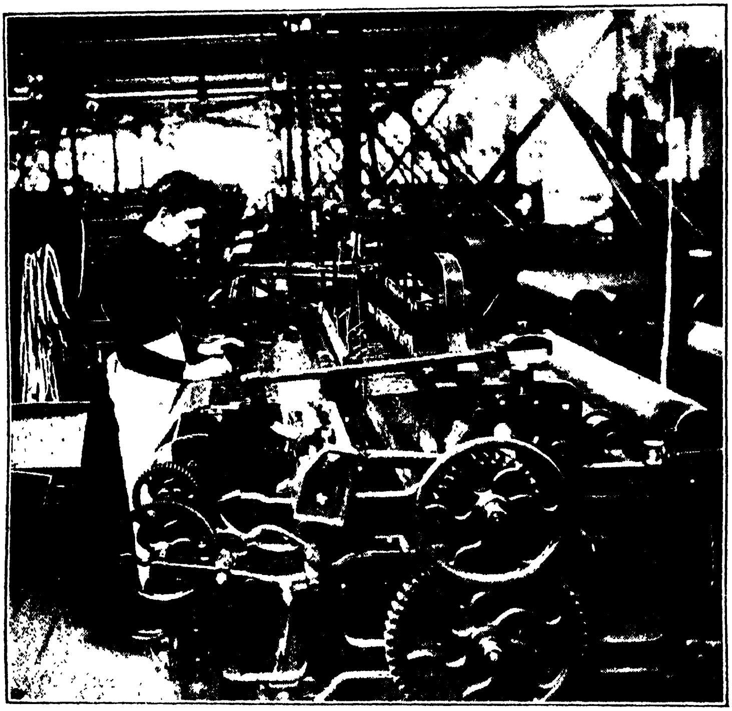
183. SETTING FOR COMPTON LOOM (R. Smith & Son, Kidderminster)

Compton Loom. But the Axminster has been brought within the machine factory by a series of inventions, of which the Compton loom is a fair representative. The Compton loom accomplishes the knotting of the tufts of worsted into the warp by mechanical means. The main feature of this loom [182] is an endless lattice chain, on which are swung rollers wound with the worsted from which the pile warp is to be formed. Other features of the loom must be carefully studied.

Setting. Our first duty is to prepare the rollers which supply the pile of the carpet. The

worsted has been washed, dried, and wound on large bobbins. According to the design, the worsted bobbins are selected and placed on the setting machine. On the creel at the back of the machine [183] the bobbins are arranged in order, and a roller is put into the machine. When the required amount of yarn has been wound, a knife comes up and severs the worsted, and another roller is ready for work. Thus, with swift facility, the rollers are wound.

Weaving. The roller holders are taken to the loom and hung in proper order on the endless swivel chain, geared on the frame above. On the loom the warp beam has been placed, and in the slay the shuttle is ready. Just when the linen warp sheds, the holder with the pile yarn comes into contact; it automatically turns over; nippers come up and grip the ends; on the tense worsted a swift knife strikes, leaving a set of short threads in the gripping jaws. The nippers turn over, and insert the short threads into the warp of the loom. Warp and weft loop round the pile, and the slay drives them tightly together. A row of tufts has been accurately woven into the carpet. In this way Axminster carpets, as heavy and strong as any knotted by hand, are made at the rate of forty yards per day. The lattice chains of rollers can be made any length, and therefore the possible variations in pattern are practically limitless.



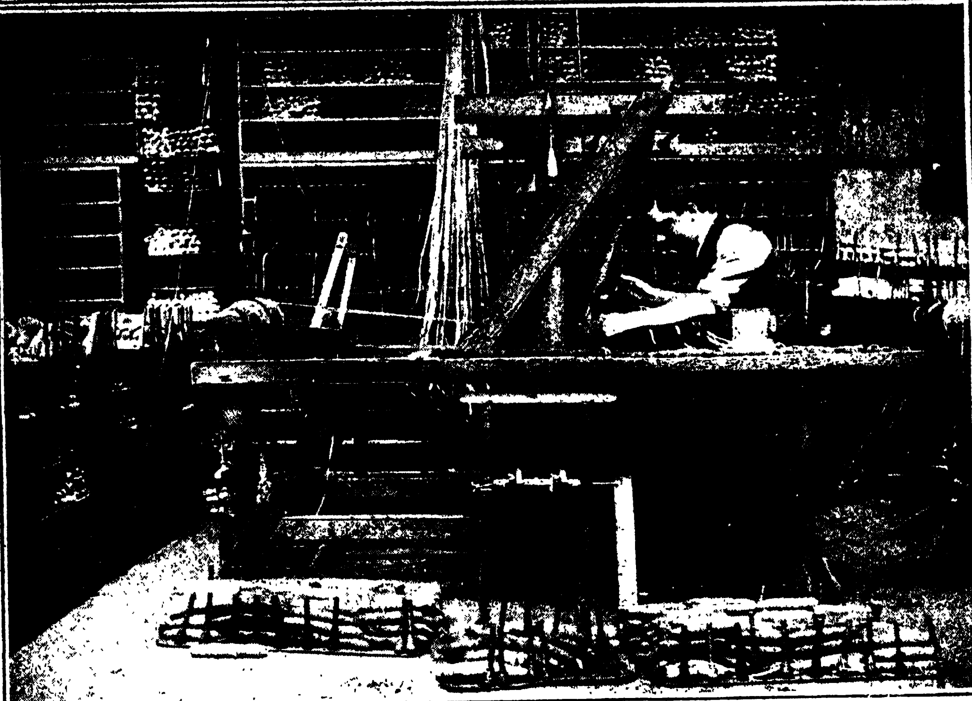
184. POWER LOOM FOR CHENILLE WEAVING (Jas. Templeton & Co., Glasgow)

Patent Axminster. In the year 1839, long before anyone else had been able to suggest a way of lessening the cost of the hand-knotted carpet by the application of mechanical invention, a Paisley manufacturer named James Templeton conceived the idea of forming a pile of the tufted carpet by weaving into a warp the chenille fringes then being largely used for edging shawls. Obviously, if we fasten strings of fringe together, a pile surface will be produced. There are two weavings in the making of the patent Axminster carpet, but neither involves any new principle. Adaptation is the word which gives the key to the process of making this fabric.

Forming the Pile Weft. When the design of the carpet has been put on the working paper, it is cut into vertical strips, which are laid end to end. The long strip thus made constitutes the length of the chenille web. By following the variation of colour marked on the strip, the weaver [185] will make chenille of the pattern required for forming the design of the carpet. He must be careful, however, to see that the strips, when folded one on the other, will remake the pattern. The right-hand end of the second strip must be joined on to the right-hand end of the first strip, the left-hand end of the third strip on to the left-hand end of the second strip, and so on, right to the last strip of the pattern. This strip is given over to the weaver, who lays it parallel with the warp on the loom.

The chenille loom, as we have already learned, has a linen warp the threads of which are set in sections wide apart, so that the weft may float free between the warp threads. Otherwise the loom is simple, when worked by power [184]. Say that there are five colours in the carpet. We have five shuttles of different colours ready to place in the shuttle-box. Looking at the pattern fixed on the side of the loom, we find that the first four squares are green; therefore, we take four picks of green. Next two squares are bronze, and we make two picks of bronze weft; next is a pick of black; and right on. By this action we produce a fabric of coloured stripes. When fully woven, the web of chenille is taken off the loom. Now the web is brought to a cutting machine, whereon the warp threads are cut into halves, and the whole web is formed into strips exactly resembling the pattern strip; this is the chenille weft for the carpet.

Weaving the Patent Axminster. If the chenille be light, it is wound on spools and put into shuttles, like ordinary weft; but

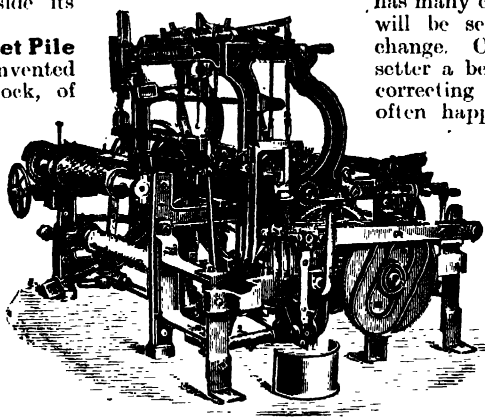


185. HAND LOOM FOR CHENILLE WEAVING (Jas. Templeton & Co., Glasgow)

186. WEAVING PATENT AXMINSTER CARPET (Jas. Templeton & Co., Glasgow)

for the large carpets we have still to depend on manual labour [186]. The chenille is wound on to spools, certainly; but the heavy threads are let out by hand, one man holding the one end and another the other, while they place it on the warp of the great carpet. At the same time another weaver gives the picker a stroke, and sends the binding shoot of linen thread across the web; then all pull forward the heavy slay, and drive home the binding weft and weft pile into the warp. As we have said, the weaving is all plain and easy work; there is no new principle involved; but the work calls for considerable care and judgment as well as the skill that comes from practical experience. We should say that the patent Axminster gives a strong and compact carpet, and no design is outside its compass.

Tapestry and Velvet Pile Tapestry Carpets. Invented by Mr. Richard Whytock, of Edinburgh, about the year 1840, this form of carpet has gained a larger sale than any other. One very plain reason for this is its cheapness; but it has other merits, and people who are beyond considering a few pounds in the furnishing of a house frequently prefer the tapestry carpet for the floors of some of the smaller rooms of the home. This apart, the tapestry carpet appeals to the largest carpet-using public, and in consequence the tapestry-carpet loom [187] has been brought to a higher productive capacity than any other carpet loom. One who has studied and worked the ordinary power-loom need have no fear about undertaking to weave in the tapestry-carpet factory; but some experience and careful observation will be needed before the requisite expertness can be attained. Females may work the light and narrow looms, but the broad looms are almost exclusively in charge of men.



187. TAPESTRY CARPET LOOM
(Robt. Hall & Sons, Bury, Ltd.)

Putting in the Web. On the tapestry-carpet loom we have practically three warps—the pile warp of worsted, the linen warp, and the filling, composed sometimes of cotton, but generally of jute. Upon the delicate adjustment of these depends a great measure of our success in weaving. The filling must always lie exactly between the linen warp threads and form the backing of the worsted. On the other hand, the worsted must start even, every thread in its place, or our pattern is ruined. If the setter has done her work accurately, and all the threads of the pile warp are of equal tension and set exactly to the pattern, we have not much to fear. But many things may happen, and the displacement of a single stitch may mean disaster. Suppose, for example, one tick of green tips the pink point of a rosebud all the way through the web, and the thread on which it is printed has got slightly drawn out of range, the slight divergence may not be observable elsewhere in the masses of colour, but always at that one point the defect will appear. If this particular thread has many changes of colour, the flaw will be seen at the edge of every change. Of course, this gives the setter a better chance of seeing and correcting the defect, and it more often happens in the former case suggested. The time of getting in a web is an anxious one for all the parties concerned, and no one breathes quite freely till everything has been shown to have come out correctly.

Weaving the Tapestry Carpet. The loops of the tapestry carpet are formed by the wires in the same way as in the Brussels, and the mechanism employed is similar. We have here no jacquard or other elaborate apparatus to mind; the whole operation is simple and straightforward plain weaving. Of one thing the weaver must be wary. Because of the force demanded from the reed in driving home the weft, the loose reed has not been adopted on the tapestry loom to any extent. In consequence, accidents with the shuttle are not uncommon. The weaver should always see that the race is plumb with the shuttle-box, and that the shuttle does not jump, even to a slight degree. Balance is difficult to maintain in a loom so heavily driven, and the temptation is to trust to luck and get through with the work; but the weaver who makes a study of his loom and readily detects the merest disturbance of the harmony of its working is most likely to weave quickly and well.

Continued

THE AGE OF ELIZABETH

The Queen and the Woman. Her Treatment of Mary Queen of Scots. The Spanish Armada. Walter Raleigh. The Great Age of Literature

By JUSTIN McCARTHY

ELIZABETH now came to the throne. She was twenty-five years old, and had been brought up in the principles of the Reformation. She had received a liberal education, and was an accomplished scholar. She loved literature, knew the great classic authors, spoke French and Italian fluently and read the literature of those countries. She was fond of music and skilled in its expression, and was a brave and well-trained horsewoman.

Character of Elizabeth. Her character was made up of contrasting emotions and inclinations; she was sensual and vain, and could enjoy any amount of flattery, no matter how extravagant, yet she had an unusual amount of clear and practical commonsense. While she passed with many of her courtiers as a merely frivolous creature who could easily be won by the most fulsome praises, she was quietly taking their measure and making them her instruments and puppets. Her coming to the throne was received with rejoicing by the Protestants, who saw that her reign would put an end to the persecution of the Reformed religion; and it was also received with hope by many Catholics, who believed, from their reading of her character, that she would trouble herself little about religious questions so long as she had a brilliant Court and could amuse herself according to her own tastes.

It is not probable that Elizabeth felt very deeply on religious matters, but her shrewd understanding soon taught her that her place in life must be that of a great Protestant ruler. The Pope, Paul IV., declared that he regarded her as illegitimate and could not sanction her claim to the succession, and that as England was under the control of the Papacy she must resign her pretensions to the throne. The Pope's action only served to convince the Protestants of England that they must stand by her sovereignty or submit to England's becoming a servant of the Papal rule. It seemed to them that to be an English Protestant was to be an English patriot. Elizabeth adopted the policy of the persecution of the Catholics, probably believing that she could not secure the safety of her throne, or the independence of England from foreign interference, by any other course.

Elizabeth and Mary Queen of Scots. One of the events of Elizabeth's reign most damaging to her character in history is the manner in which she acted towards Mary Queen of Scots. Mary has ever been one of the most romantic figures in history. She was a woman of great beauty and charm, and of much intellect and culture. She went through many successes and misfortunes before the time when, in a moment of despair, she threw herself on the protection of Queen Elizabeth. Mary went to France in 1548, and was affianced to the Dauphin. She passed the next ten years at the French Court, where she received an excellent education. In 1558 she was married to the Dauphin, who on the death of the French King succeeded to the throne; but he died in the following year, and some struggles then began in France for the succession and control of the administration.

An Unfortunate Marriage. In Scotland the death of Mary's mother had left the State without a head, while the country was much disturbed by the followers of the old religion and the new. Mary had no desire to enter into that contest, and as the Reformers claimed to have the sanction of the Scottish Parliament she allowed them to take their course, while maintaining her own right to follow the teaching of the Catholic Church. Her reign went on for some time in comparative peace and prosperity. It was soon thought necessary, however, that she should find a husband, and the Archduke Charles of Austria, Don Carlos of Spain, and many other nobles at home and abroad were suggested as candidates for her hand. Mary would have chosen Don Carlos, but this not being satisfactory to her Parliament, she suddenly decided to marry her cousin, Lord Darnley, whose mother was a granddaughter of Henry VII. of England. The marriage was in every way most unfortunate for Mary. Darnley was worthless and vicious, and she was soon repelled by his immorality and alarmed by his selfish ambition. Darnley had obtained from her the title of King, but when he tried to induce her to secure the crown to him for life, and to his heirs if she should die without leaving a child, Mary refused to give her consent.

Rizzio and Lord Darnley. Mary's leading Minister since she returned to Scotland had been her half-brother, the illegitimate son of James V., James Stuart, a Protestant, whom she had made Earl of Moray. On Mary's marriage with Darnley, Moray and some other Scotch nobles had rebelled against her, but the rebellion was easily suppressed, Mary dealing mercifully with the offenders. Since then Mary's principal adviser had been David Rizzio, an accomplished but not judicious or trustworthy Italian, whom Darnley had hitherto regarded as one of his most devoted friends. When Mary refused to satisfy Darnley's ambitious designs he at once regarded Rizzio as the cause of her refusal, and believed that he was her lover. Darnley persuaded some of the great Protestant nobles that Rizzio was influencing

the Queen against the Protestant Church, and on March 9th, 1566, he broke into the Queen's room with a number of his new allies, and held her while they dragged Rizzio away and murdered him.

Notwithstanding this, Mary still received her husband as before, and even succeeded in drawing him away from his recent allies. She may have forgiven him on account of his jealousy, or she may have determined, as a Catholic, not to renounce the man to whom she was married. Another reason may have been that a child of their marriage was about to be born. On June 19th, 1566, Mary gave birth to a boy, afterwards James I. of England and VI. of Scotland.

But before long Darnley's character became more repulsive than ever, and there was again some question as to the possibility of a divorce. The separation, however, was not destined to be accomplished by mutual consent or the operation of the State. In January, 1567, Darnley was attacked by smallpox at Glasgow, where Mary visited him and brought him back to Edinburgh. He was placed in a house outside the walls of the city, close to the Kirk o' Fields; and throughout his illness Mary attended him constantly, sleeping in a room below his bed-chamber and passing the evenings with him. On the night of Sunday, February 9th, she left him to go to a festival in Holyrood Palace in honour of the marriage of a favourite servant. About two hours after midnight the house in which Darnley was lying was blown up by gunpowder, and his body was found afterwards in the garden.

Bothwell. Public opinion in Scotland at once ascribed the crime to James Hepburn, Earl of Bothwell, a Scottish noble who had been much favoured by the Queen Regent, and raised to high official position by her although he had long declared himself a Reformer. In 1560, he was sent by Mary of Guise on a mission to France, and there he first met the Queen of Scots, who, when she returned to Scotland, made him a Privy Councillor. He was an ambitious and audacious man, and his schemes brought on him imprisonment in Edinburgh, and, later, exile to England and to France. After her marriage Mary recalled him, and restored to him all his dignities. Bothwell was brought to trial as the author of Darnley's murder, but was acquitted, and the trial was regarded by the public as a mere sham. Within less than a fortnight after his acquittal, he captured Queen Mary as she was passing from Linlithgow to Edinburgh. She offered no resistance, and he carried her to his place at Dunbar. Bothwell had been married not long before to a charming young woman, from whom he now obtained a divorce. Mary gave him a public pardon for his seizure of her person, and created him Duke of Orkney, and within three months after her husband's murder became the wife of the man whom the whole country regarded as the author of the crime.

This brought all her leading nobles into open rebellion against her, and the feeling of the country now condemned her as it condemned her new husband. It was believed by some that Mary was a party to the plot for the murder of Darnley, or at least a tacit accomplice, although this was never proved. The army she had raised to resist the forces of the nobles dissolved without striking a blow when they showed themselves in battle array, and Mary was compelled to surrender. She was consigned to a prison in the island of Loch Leven, and forced to sign an act of abdication in favour of her son, who was immediately proclaimed King at Stirling. After a long imprisonment, she contrived to escape and to rally to her side a small army of about 6,000 soldiers, which was utterly defeated by the Regent, Moray. Then it was that she threw herself on the protection of Queen Elizabeth, and by that act brought about the close of her strange career. Although she was kept a prisoner, her presence in England was a source of continual trouble to Elizabeth and her counsellors.

Execution of Mary Queen of Scots. Mary had still many supporters among the Catholics of these countries and of France, Italy, and Spain, who refused to believe her guilty of any crime, and regarded her as the last hope of the restoration of the old Faith. Several plots were made for her release, and even for the assassination of Queen Elizabeth. It was said that letters from Mary were discovered during the trial of some of the plotters showing that she was a consenting party to their projects. She was put on her trial in September, 1586, found guilty, and sentenced to death. Elizabeth was for a time reluctant to sign the death warrant, and seems to have felt some doubt of the genuineness of the conviction, and some consideration for her unhappy captive. The Queen was at last prevailed on to sign the warrant, and on February 8th, 1587, Mary was put to death on the scaffold. To the last she bore herself with a composure and a queenlike dignity which deeply impressed all the beholders. She was buried at Peterborough, and some years after her body was removed to the Chapel of Henry VII., where it still remains in a tomb raised by her only son, James I.

After the death of Mary, the Government of Queen Elizabeth increased in severity towards the Catholics. An Act passed in 1585 declared the presence of a Catholic priest in England to be treasonable, and his protection to be felonious, measures which were in many instances enforced. Such enactments, and the unsparing rigour with which they were carried out, aroused the strongest feeling of hostility among the Catholic nations, especially in Spain.

The Spanish Armada. Philip II. of Spain was himself a persecutor of faiths not his own, but he was none the less fervent in his denunciations of the persecution of the Catholics by Queen Elizabeth. He had other grudges against England as well as religious and political ones, for he had not only been an unsuccessful suitor for the hand of Elizabeth, but his policy in the Netherlands had been much opposed in England. He had long contemplated an attack on England, and had even allowed his intention of invading England to avenge the death of a

Catholic queen, and to restore her religion, to be publicly known. He had spent some years in maturing his plans, and the Armada of 1587 consisted of 130 large ships, more than 3,000 cannon, 8,000 sailors, 10,000 galley slaves, 20,000 soldiers, and some 1,400 volunteers, chiefly noblemen and their attendants. The whole Armada was commanded by the Duke of Medina-Sidonia. The English fleet, hurriedly prepared to encounter the invasion, consisted of 80 vessels under the command of Lord Charles Howard, Sir Francis Drake, and Sir John Hawkins, and there were three armies on shore to repel the invaders should they effect a landing. The Armada sailed from Lisbon in May, 1588, but was dispersed by a violent storm. The fleet was soon got together again, and it actually entered the English Channel off Cornwall on July 28th, 1588. A series of engagements followed, in which the Armada suffered heavy losses, was dispersed by fireships, and had many vessels captured or sunk by the English.

Elizabeth had been slow to admit the seriousness of the danger, and her endeavours to keep down the expenses of the naval preparations led to the English victory being less rapid and complete than it would otherwise have been.

But in spite of this it soon became evident to the Spanish commanders that the day was lost, and they began their retreat to Spain in the opening of August, suffering heavily from the stormy weather. The Spanish are computed to have lost 35 ships and 13,000 men.

The Age of Literature. The reign of Elizabeth was the greatest age of literature England has seen, and may challenge comparison with any era of the world. The name of Shakespeare alone would immortalise the reign. It was also the era of Edmund Spenser, of Sir Philip Sidney, of Marlowe, of Massinger, of Ben Jonson, and of many other great men whose works, if they do not retain at the present day their full popularity, are yet standard productions of poetic and dramatic literature. [See LITERATURE.]

Another great man of a different order, also an author, was Sir Walter Raleigh, a daring and successful soldier and explorer, some of whose highest triumphs were achieved during the reign of Elizabeth. But her chief favourite was Robert Dudley, Earl of Leicester, an attractive and brilliant but insincere and self-seeking man. Elizabeth was so taken with Leicester that she would undoubtedly have married him but for the remonstrances of some of her most influential advisers. After Leicester's death, Elizabeth took into her special favour Robert Devereux, Earl of Essex, but it is generally believed that her affection for him was maternal rather than lover-like. A quarrel arose between them, and according to stories told at the time, Essex turned his back upon her, and the great Queen forthwith boxed his ears. The two were never thoroughly reconciled. Essex afterwards plotted against Elizabeth, was found guilty of high treason, and on February 25th, 1601, was beheaded in the Tower.

Elizabeth and Ireland. Whatever may have been Elizabeth's faults, she unquestionably had a sincere devotion to what she believed to be the interests of England. In a speech to her first Parliament, she declared that "Nothing, no worldly thing under the sun, is so dear to me as the love and goodwill of my subjects." In this we may credit her with sincerity, and it is certain that she was a most popular sovereign with all those of her subjects who clung to the principles of the Reformation. She was unpopular in Scotland among those who favoured the cause of Queen Mary, and as unpopular in Ireland, where she suppressed several rebellions and where her name is held to this day in detestation by the majority of the people. One of the most famous of her opponents in Ireland was Shane O'Neil, who belonged illegitimately to the great house of O'Neil, on the head of which Henry VIII. had conferred the Earldom of Tyrone. The title carried with it, according to English law, the principle of hereditary descent, but in Ireland the clan or family were allowed to choose any member of the house to be its chief. Thus, on the death of the first earl, Shane O'Neil was chosen as his successor.

The endeavour to enforce the Reformation principles in Ireland had aroused bitter resentment and hostility among the Irish, and the national cause had become a religious one as well. Shane O'Neil, already distinguished in his country by his devotion to the Irish cause, proclaimed himself the champion of Ireland's restoration to national independence. Elizabeth, amid all her troubles with foreign States, had to send a large army into Ireland, for Shane proved a formidable enemy. The Queen seems to have been attracted by the character of the rebel, and to have been inspired by the idea that she might win him to loyalty if she had an opportunity of discoursing with him. She invited him to visit her at her Court, and expressed a hope that she and her Irish people might be able to come to terms. O'Neil accordingly went to England with a number of his retainers.

An Unsuccessful Ambassador. The negotiations, however, came to nothing, and he was retained in London rather as a captive than as an ambassador. Eventually the Queen made it known that O'Neil was to be regarded in future as a loyal subject. But when he went back to Ireland he declared that he had been compelled to accept the terms under peril of captivity or death, and again rebellion broke out.

O'Neil came to his end in a manner unworthy of his position as an Irish leader. In June, 1567, a quarrel broke out at a drinking festivity between him and some men who had been tribal enemies of his. The quarrel became serious, and Shane and some others were killed, and Ireland remained in a state of rebellion against England, more or less, through several generations

In her later years Elizabeth sank into ill-health, and she died at Richmond on March 24th, 1603. With her death came to an end the dynasty of the Tudors.

Continued

Group 8
DRAWING
28

TECHNICAL DRAWING continued from page 3925

CHAIN GEARS AND CLUTCHES

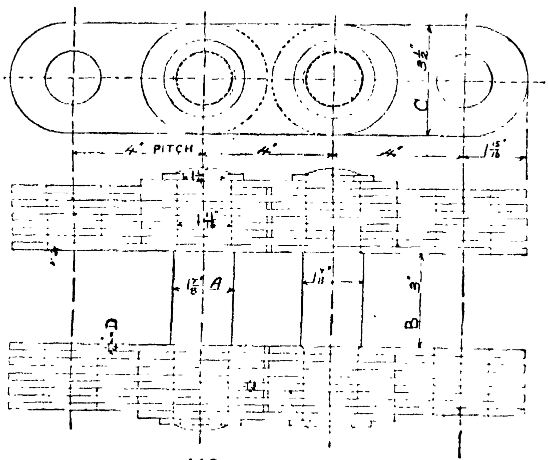
Stud Chain. Block Chain. Bush Roller Chain. Renold Silent Chain. Friction Wheels. Friction Cones. Friction Clutches

By JOSEPH W. HORNER

Gearing Chains. Gearing chains are used for transmitting power in cases where a flexible yet accurate drive is required. Their leading applications may be enumerated as follows: Driving steam-engine governors; driving line shafts from electric motors; driving motor-car axles; driving pumps and machine tools from electric motors; driving feed gears of machine tools; driving grain elevators and general conveyor work; travelling gear of steam and electric cranes; agricultural machinery, etc; hoisting tackle for pulley-blocks and cranes. There are various types of gearing chains in use and each type has its sphere of application more or less distinct from its fellows.

The leading types are the *stud chain*, the *block chain*, the *bush roller chain*, and the *patent silent chain*.

The Stud Chain. Fig. **119** shows a heavy stud chain as used for hoisting tackle. It is designed for a working load of 10 tons, and a factor of safety of 10, consequently its breaking load would be 100 tons; a chain of this nature is designed simply for strength, and has not sufficient wearing-surface to render it suitable for transmitting power except at very slow speeds, not exceeding, say, 50 ft. per minute.



119. STUD CHAIN

A table is given on this page showing the principal dimensions of this type of chain for various loads. The factor of safety varies in practice from 6 to 10; the loads given in the table are breaking loads, and must be divided by a factor of safety to obtain working loads. This chain is sometimes termed *pin and link chain*.

The Block Chain. This is suitable for speeds up to 500 ft. per minute. The block may be hollowed, or flat; the design of this chain, as well as those which follow, is based upon the provision of ample wearing-surface rather than upon actual strength; the proportions are settled by practice rather than by calculation. Accordingly the selection of a chain for any particular duty is best left in the hands of expert manufacturers such as Hans Renold, Ltd., of Manchester, whose reputation is world wide. Fig. **120** illustrates a working drawing used in the manufacture of such chains.

It will be seen that not only are all the details fully dimensioned, but the drawing-sheet contains data with regard to quantities and to material; the perspective view of the block gives a good idea of its shape at a glance. Another feature to be noticed is the extreme exactness of the dimensions, vulgar fractions being inadmissible with the accurate machinery used in the manufacture of the chain.

The Bush Roller Chain. Suitable for speeds up to 800 ft. per minute, the construction of this chain will be seen from **123** A and **123**B, which is a reproduction of a Renold working drawing. The rivets of the chain carry hardened bushes, which form a bearing for the anti-friction rollers which engage with the wheel teeth. The latest practice of Hans Renold, Ltd., in the matter of issuing shop drawings is to show each component part on a separate card, each 6 in. long by 5 in. wide [**121**]. The advantages of using the cards are briefly these: (1) The workman has only the drawing of one item in front of him, and since that is the one which he is

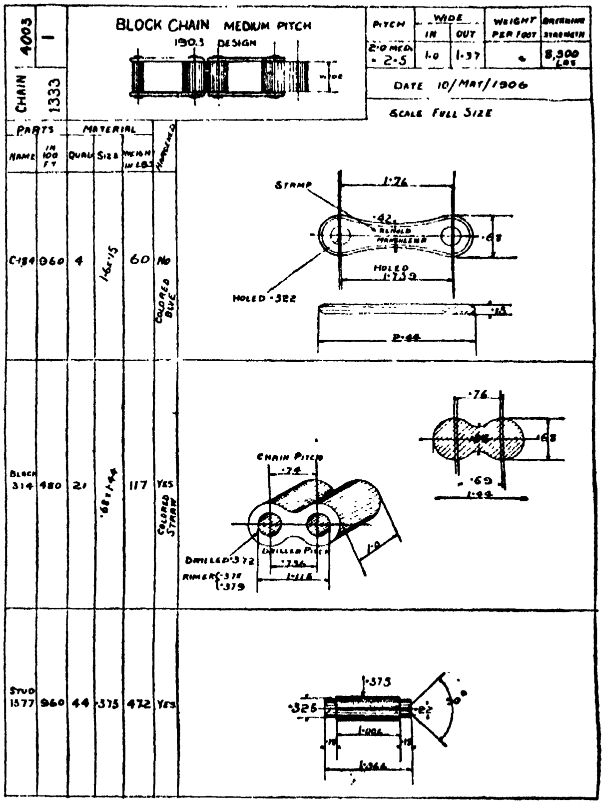
DIMENSIONS OF STUD CHAINS

Breaking load in tons.	Pitch in inches.	A	B	C	D	No. of plates.
$2\frac{1}{2}$	1	$\frac{3}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{1}{8}$	2
5	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{3}{32}$	4
$7\frac{1}{2}$	$1\frac{1}{2}$	$\frac{9}{16}$	1	$1\frac{1}{4}$	$\frac{3}{32}$	4
10	$1\frac{3}{4}$	$\frac{11}{16}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$\frac{1}{8}$	4
$12\frac{1}{2}$	$1\frac{7}{8}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$\frac{1}{8}$	6
15	2	$\frac{7}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$\frac{1}{8}$	6
20	$2\frac{1}{8}$	1	$1\frac{5}{8}$	$1\frac{5}{8}$	$\frac{5}{32}$	6
25	$2\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	$\frac{5}{32}$	6
30	$2\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{7}{8}$	2	$\frac{3}{16}$	6
40	$2\frac{7}{8}$	$1\frac{1}{4}$	$2\frac{1}{8}$	$2\frac{1}{4}$	$\frac{3}{16}$	8
50	$3\frac{1}{8}$	$1\frac{3}{8}$	$2\frac{5}{8}$	$2\frac{3}{8}$	$\frac{3}{16}$	8
60	$3\frac{3}{8}$	$1\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$\frac{7}{32}$	8
80	$3\frac{3}{4}$	$1\frac{3}{4}$	3	3	$\frac{7}{32}$	10
100	4	$1\frac{7}{8}$	3	$3\frac{1}{2}$	$\frac{1}{4}$	10

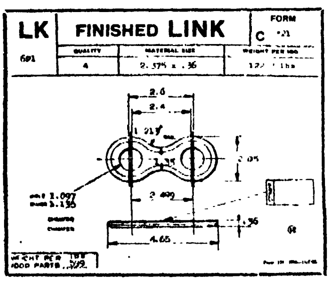
concerned with, no time is lost in having to pick his part off a drawing containing other work; (2) if an alteration is to be made it entails only the calling in of a few cards and the issuing of revised ones, the incoming cards being destroyed, but when the whole drawing [123] is involved, it is a much more troublesome and expensive matter to put right; (3) the whole drawing is retained in the drawing office, and assembly cards, as 122, are issued for putting the parts together.

The Renold Silent Chain. The honour of designing and constructing the only satisfactory high-speed chain belongs to Hans Renold; 1,250 ft. per minute can be attained with this chain [124]. The construction is unique, and the action of engaging with the wheel teeth is entirely different to ordinary chain gears. In order to understand this better we will first investigate the action of ordinary chains and the formation of wheel teeth.

Fig. 125 illustrates a wheel suitable for working with the chain shown in 119; the tooth curves are involute, and there is just enough space at the roots for the easy working of the studs as the chain enters and leaves the teeth. This is the simplest form and works satisfactorily with slow speeds and uniform loads. As speeds increase and loads vary, this construction must be modified; the best-made chain will stretch, and then the wheel has to accommodate a varying and an increasing pitch. Another complication has also to be met; the driving wheel has a tendency to run faster than the chain, while the driven wheel tends to lag behind the chain; this effect is seen in 126, which is slightly exaggerated in order to show the clearing allowances made. The pitch of the teeth is greater than the pitch of the chain in the case of the driving wheel, and the tooth spaces are much wider than actually required for the accommodation of the roller alone; by such construction the above-mentioned difficulties are overcome, but the life of the chain is seriously impaired if run beyond a speed of, say, 800 ft. per minute. The difference in pitch between the chain and the wheel gives rise to a series of little shocks as the load is transferred from tooth to tooth while running, such shocks being the cause of the wear and noise which limit the speed.

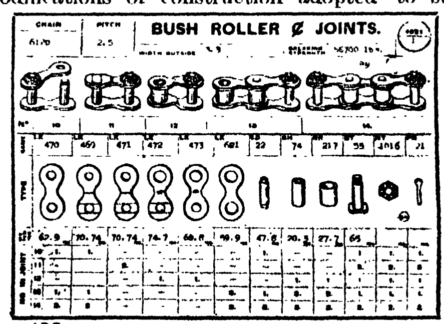


120. BLOCK CHAIN DRAWING

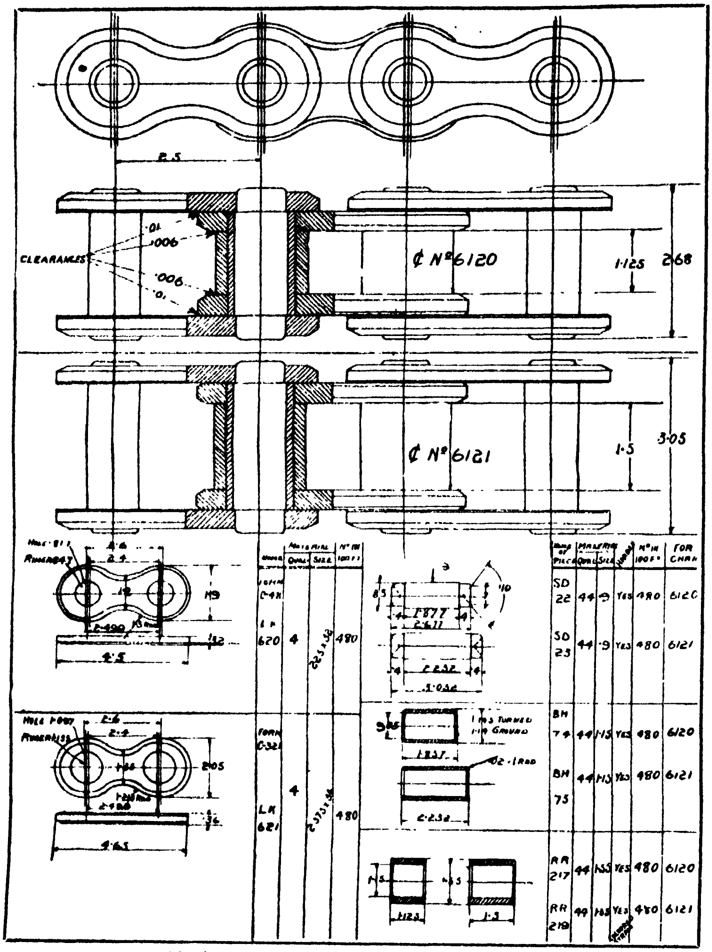


121. FINISHED LINK DRAWING CARD

The Patent Silent Chain. Referring now to the patent silent chain [124], we see that the action of the links is to come quietly into position without slide or shock; when the teeth are worn, or when the chain is stretched, the chain rises automatically up the wheel tooth, as in 127, and so accommodates itself to altered conditions, and maintains a silent drive. The chain consists of a number of links of the outline shown, there being from 4 to 12 abreast according to power transmitted. There are various modifications of construction adopted to suit



122. ASSEMBLY CARD FOR BUSH ROLLER CHAINS



123A. BUSH ROLLER CHAIN DRAWING

different drives, but the above principles do not alter.

Chain Wheels. Chain wheels are ordinary castings for heavy stud chains, but are invariably machine-cut for all other types. The diameter of a wheel is naturally kept as small as possible in order to keep the chain speed down, and also to save expense. When using *block chains* the limit of teeth in the pinion may be taken as six, although smaller ones have been employed for special work. With *roller bush chains* eight teeth are considered to be small enough for ordinary work, while the ratio of the wheel and pinion should not be more than 7 or 8 to 1. The smallest wheels for the patent silent chain should not contain less than 15 or 18 teeth, according to construction of chain ; the *gear ratio* recommended should not be more than 5 to 1.

It is desirable to arrange a gear drive so that it contains an even number of links or pitches ; when this is unattainable recourse is had to special links as shown in the top right-hand corner of 123B, where they are cranked to fit outside of the links they would come abreast of.

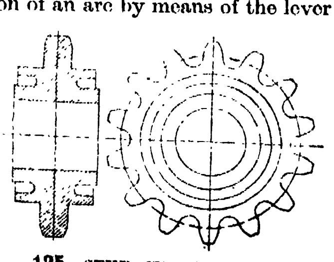
Chain Belting. A chain belt is a form of metallic chain used largely for elevating and conveying machinery ; the links are invariably of malleable cast iron. The design and manufacture of this chain is even more in the hands of specialists than that of the foregoing types, consequently the draftsman is rarely or never called upon to design them.

Friction Wheels and Clutches. These are used for the transmission of power, at intermittent intervals, from constantly-moving machinery; or for rapidly disconnecting a portion of moving mechanism ; or for connecting machinery to engine after it has started up. A common application of the latter form is met with on motor-car work, where the engine is not capable of starting up against full load.

The principles underlying this class of mechanism are discussed on page 958, and applications are illustrated on page 961 and 963 in MECHANICAL ENGINEERING. We therefore proceed to delineate more fully several leading types.

Fig. 128 shows a flat-faced friction wheel and pinion as used on a friction hoist. The wheel is keyed to the rope-barrel of the hoist, and the barrel runs loose upon the shaft. The end of the shaft is formed eccentrically, and is moved through a portion of an arc by means of the lever

124. RENOLD SILENT CHAIN



125. STUD CHAIN WHEEL

and cord. This movement brings the friction wheel into contact with its pinion, which latter is running constantly; the friction set up between the two surfaces causes the wheel to revolve. The barrel, being keyed to the wheel, must go with it, and so the load is lifted. The calculations involved are simple, and may be stated thus: The load to be lifted is 1 ton, the corresponding load on the periphery of the wheel is

$$\frac{\text{load} \times A}{B} = \frac{2{,}240 \times 9}{51} = 395 \text{ lb.}$$

Assuming the coefficient of friction to be ·2 (cast iron on cast iron), then the pressure required between the wheel and pinion is

$$\frac{395}{\cdot 2} = 1{,}975 \text{lb.},$$

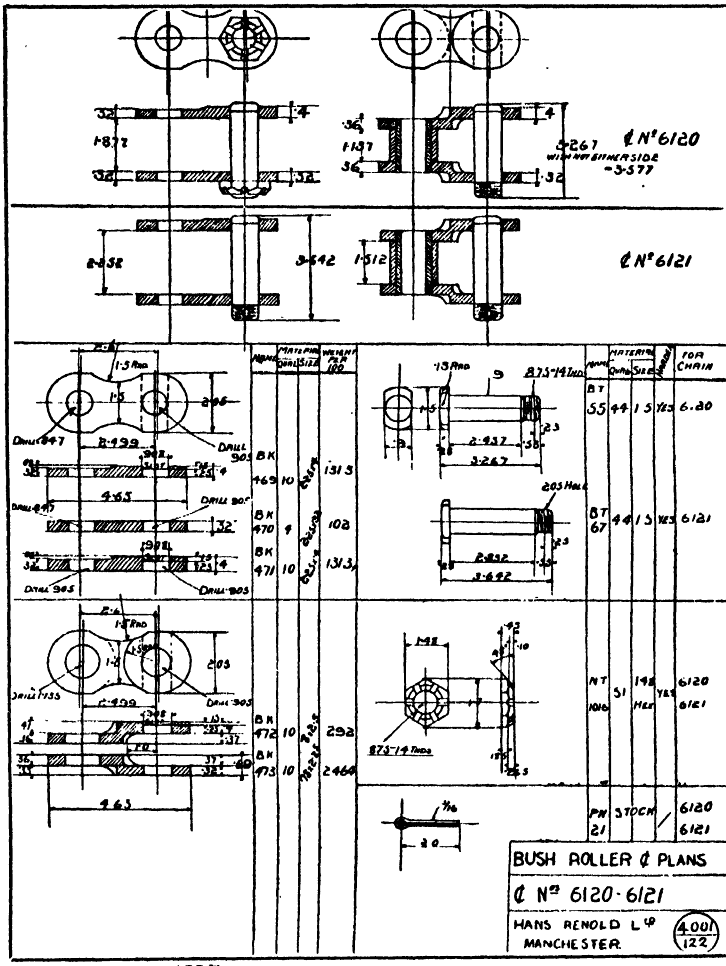
and the load on the operating cord is therefore

$$\frac{1{,}975 \times C}{D} = \frac{1{,}975 \times \cdot 75}{70} = 21 \text{ lb.},$$

which is quite within the capacity of an average man to manipulate. The pulleys are designed as ordinary belt pulleys, but are somewhat heavier throughout, to withstand shocks due to the sudden application of the load. An enlarged view of the eccentric formation of the shaft is given in 123, which is a neat way of making a very short lever arm. The weight near the end of the long lever is so placed in order to ensure the large pulley returning to contact with a brake block arranged overhead, when the hand cord is released. The width of the wheel is 6 in. in the case illustrated, and this works out to

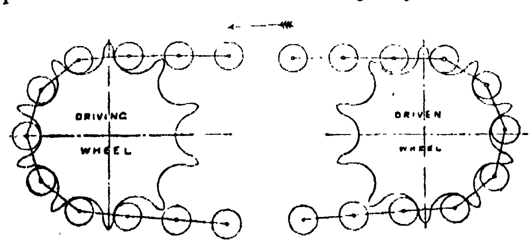
$$\frac{1{,}975}{6} = 329 \text{ lb. per inch of width.}$$

This represents average practice. High pressures per inch of width tend to heat the pulleys.

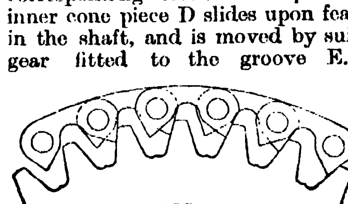


123B. BUSH ROLLER CHAIN DRAWING

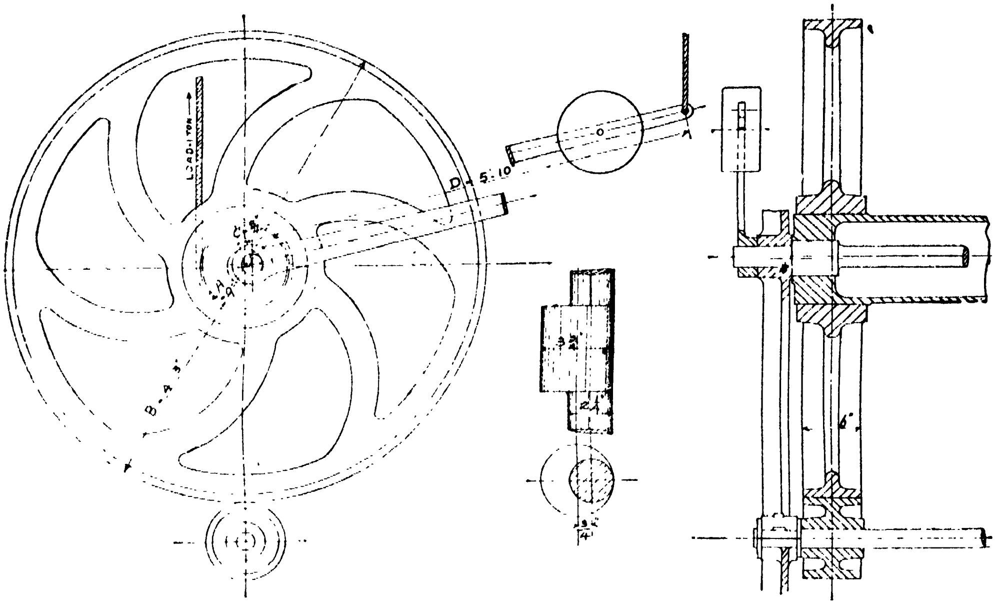
Friction Cones. Friction cones, or *cone-couplings*, as they are sometimes termed, are used for coupling shafts together while one of the shafts is running, or for taking power from a revolving shaft. The latter application is shown in 129, the view illustrated being a section, and all portions circular. The outer cone piece A is bushed and runs loose on the shaft, being kept in its place endwise by means of the collars B and C. Teeth are cast on the outside periphery, which engage with corresponding teeth of a spur wheel. The inner cone piece D slides upon feathers fitted in the shaft, and is moved by suitable lever gear fitted to the groove E. Driving of the spur gear takes place when the cones are pressed together



126. DIAGRAM OF CHAIN AND WHEELS

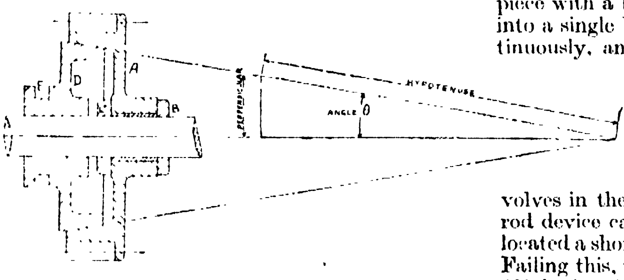


127.
RENOLD SILENT CHAIN WHEN WORN



128. FRICTION WHEELS

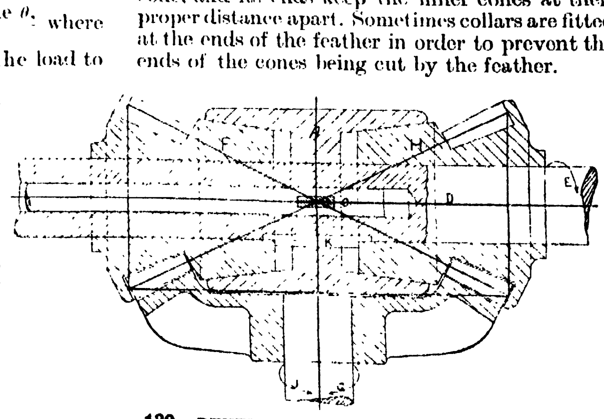
with sufficient force to overcome the resistance to slipping between their surfaces. The end pressure required depends upon the coefficient of



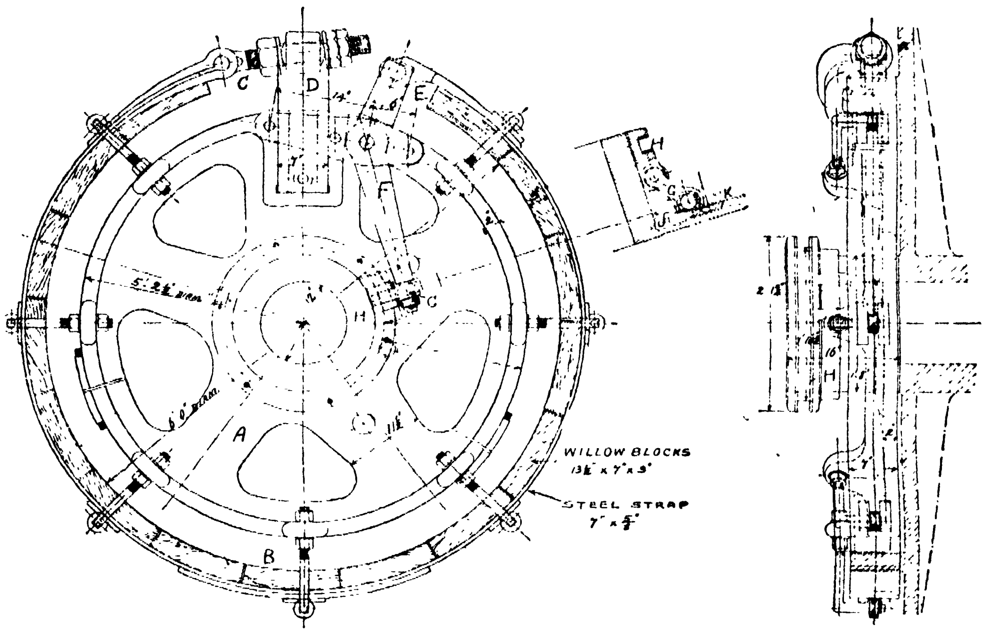
129. FRICTION CONES

friction and upon the angle of the cone. The general formula in use is $P = \frac{L \times \text{sine } \theta}{\mu}$ where P is the necessary end pressure, L is the load to be transmitted at the mean diameter of the cone. θ is used to denote the angle; "sine" is a trigonometrical ratio of the angle θ, and is found by dividing the perpendicular by the hypotenuse; μ denotes coefficient of friction. The angle θ is usually 10 deg., and μ may be taken as ·2 for cast iron on cast iron.

Reversing Cones. Another application of the foregoing type of cones is shown in **130**. The outer cone A is in this case driven from the shaft by means of the cottar B, which passes through a slot, C, in the shaft. This cottar also passes through a central rod which is moved endwise at the centre of the shaft. The outer cone is double-ended in order to engage with either the right or left hand inner cones, and these latter are each cast in one piece with a bevel pinion, and both pinions gear into a single bevel wheel; the shaft D runs continuously, and carries the outer cone with it. When the shaft is running in the direction of the arrow E, and the cone F is engaged, then the bevel wheel runs in the direction of the arrow G; but if the cone H be engaged, then the bevel wheel revolves in the direction of arrow J. The central rod device can only be used when the cones are located a short distance from the end of the shaft. Failing this, they may be moved, as in the case of **129**, by forming the groove around the centre of the outer cone. The feather K assists to drive the outer cone, and its ends keep the inner cones at their proper distance apart. Sometimes collars are fitted at the ends of the feather in order to prevent the ends of the cones being cut by the feather.



130. REVERSING FRICTION CONES

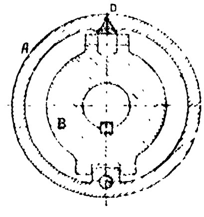


131. THE "WELLMAN SEAVER MORGAN" CLUTCH

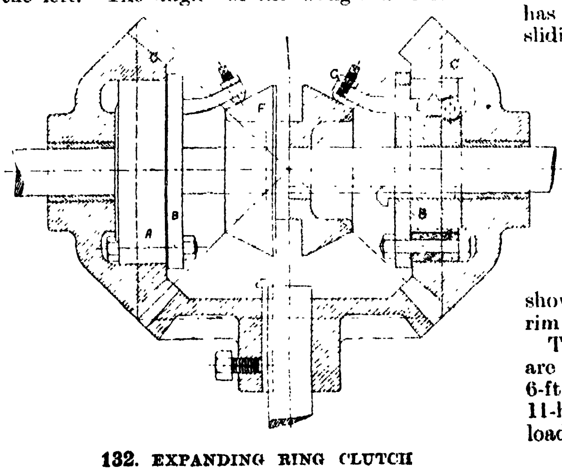
Friction Clutches. The principal objection to the use of the friction devices just described is the resulting end pressure upon the bearings of the shafting. Figs. **131** and **132** show two friction clutches which are practically free from this defect.

An *expanding ring clutch* is seen in **132**. It is double-ended or reversible. The expanding ring A is driven from the shaft by key and by the piece B. It is expanded to drive the hollow of the mitre wheel C. In order to effect the expansion, the ring is divided at D, and receives a steel wedge piece, which is forced up by another wedge formed on lever E. This lever is moved by striking the cone piece F to the right or to the left. The angles of the wedges and of the cone are such that they slip back when the pressure is removed. The adjusting screw G on the end of the lever provides means for following up the wear on the working parts, and so keeping the relative stroke of the cone a constant.

A friction clutch which has wide applications amongst mill work and winding engines, and can be built to transmit thousands of horse-powers, is shown in **131**. It is made by the Wellman Seaver Morgan Co., Ltd. It consists of a centre driving disc A, which is keyed to the shaft, and carries with it a wood-lined strap, B, which is adjustable by means of its anchored end, C, on driving piece D, and is tightened by the end marked E and the lever F, the tail end of which has a spherical connection with the link G. The sliding collar H is moved by suitable striking levers, and causes the link G to move the ball end of the lever F from position J to position K. The strap is thus tightened upon the rim of any drum or wheel which may be interposed between the strap and the driving disc A, as shown in chain dotted section. Such interposing rim does not have any contact with disc A.



The leading dimensions of one of these clutches are given on the drawing [**131**], which is a 6-ft. diameter example, and can transmit 11-horse power per revolution, with a maximum load of 20,000 lb. on the rim.



132. EXPANDING RING CLUTCH

Continued

THE USE AND ABUSE OF DRUGS

Remarkable Properties of Drugs and Beverages. Value of Tea and Coffee. The Ridiculous Claim for Alcohol, Morphia, Opium, Tobacco, Strychnine, Quinine

By Dr. C. W. SALEEBY

Opium and Civilisation. We must now turn to a detailed discussion of a few of the most important vegetable alkaloids, and we shall begin with what for ages has been recognised as the most valuable of them all—a substance which has no rival in relieving pain, and which, unfortunately, by a perversion of the power of science has lately become accessible to all and has added another and a most terrible vice to our civilisation. The juice which exudes from the ripe capsules of the poppy is known when dried as *opium*. The complexity of the composition of this product is amazing. Besides morphine, it actually contains at least seventeen other alkaloids, together with some peculiar acids, and a whole host of different salts as well as some neutral principles, albumen, glucose, fats, a volatile oil, etc.

We insist upon this complexity of opium because it is obviously a very serious objection to the use of this substance in medicine No wonder it upsets many people. Of all these constituents, however, there are only two that are of the slightest value. Both are capable of ready isolation. Hence, except on the ground of expense—which in such connection is not worth considering—there is really no adequate reason why opium or its preparations should ever be used as drugs. Opium should be used merely as a source of the alkaloid *morphine*, which it contains to the extent of about 10 per cent., and of the alkaloid *codeine*, which is a methyl-morphine. The alkaloid *thebaine*, which has already been mentioned, is yearly responsible for a very large number of infant deaths since, in the case of infants, it is the most dangerous ingredient of the various patent medicines containing opium, with which the wicked and ignorant state of the law still permits many mothers unconsciously, or half consciously, or even deliberately, to kill their babies.

The Preparation of Morphine. The preparation of morphine may be briefly described, since it is fairly well indicative of the general process by which alkaloids are isolated A cold, concentrated, aqueous solution of opium is treated with the chloride of calcium or barium. This precipitates various ingredients of the opium and converts the morphine into a hydrochloride, which is precipitated in turn by the addition of ammonia. The morphine thus obtained is washed, dissolved in hydrochloric acid, and crystallised out in the form of the pure hydrochloride, which is the most commonly employed salt. This is fairly soluble, like the salts of alkaloids in general. Morphine itself is not soluble in less than 1,000 parts of cold and 300 parts of boiling water. The mo. important fact of the pure chemistry of morphine is that its decomposition, as might be expected, yields pyridin and chinolin.

Unfortunately, the higher chemistry has not yet reached a point which permits us to say anything whatever about the chemical actions involved in the effect of morphine upon the brain and other parts of the body.

Opium Poisoning. We can here briefly discuss, however, the chemistry of the very interesting subject of opium poisoning. The first fact worthy of notice is that the most efficient means of persuading the stomach to rid itself of the morphine it contains is to be found in the prompt use of the substance called *apomorphine*, which, as we have seen, is morphine minus one molecule of water. This little difference is sufficient to deprive apomorphine of all the actions upon the nervous system which are so characteristic of morphine itself; but, on the other hand, the loss of this molecule of water endows it with the property of being by far the most powerful of all known emetics.

The second point about the treatment of opium poisoning is the very great value that attaches to the administration of the permanganate of potassium, $KMnO_4$. About ten grains of this should be dissolved in one ounce of water. If Condy's Fluid is at hand it may be diluted and administered, this being a solution of the salt. Similarly, if the stomach pump is employed, eight or ten grains of the permanganate of potassium should be dissolved in every ounce of water to be used, or the stomach may be washed out with diluted Condy's Fluid. The value of the permanganate lies in the fact that it immediately oxidises any morphine with which it comes into contact, producing substances which are entirely harmless. In short, morphine is a reducing agent, and one of the tests for it consists in the decolorisation of solutions of potassium permanganate—this being due to the simultaneous destruction both of the morphine and of the salt in consequence of the transference of oxygen.

Obviously, the chemical aspect of the treatment of opium poisoning is concerned merely with the morphine that remains in the stomach. Unlike the case of carbolic acid, which can be pursued even into the blood by chemical antidotes, as we have seen, morphine, after absorption into the blood, can unfortunately not be attacked by chemical means.

The Chemistry of Morphia. Chemistry, however, has been of the greatest value in elucidating the facts, long familiar to physicians, of chronic opium poisoning or the similar poisoning due to the habit of using subcutaneous injections of morphia. The chemical

elucidation of this subject is of the greater interest because parallel facts are more than likely to be demonstrated in the case of other chronic poisonings, such as that by alcohol, which is, of course, vastly more important than even this.

Let us keep in our minds what we have already noted regarding the remarkable fashion in which the simplest and most easily effected change in the constitution of the molecule of an alkaloid may cause it, so to speak, to turn upon itself, and thus to possess pharmacological properties directly antagonistic to those which were formerly characteristic of it. Further, let us note that in many plants we find pairs of antagonistic alkaloids of which, in all probability, one is derived from the other by some such simple change as we have already illustrated. Remembering these facts, let us consider the case of chronic opium poisoning, or what, to give it its technical term, we may call *morphinomania*.

The Victim of the Morphia Habit. We find that the patient becomes depressed, irritable, weak, nervous, sleepless, and ill in many other ways at a certain definite point after taking a dose of this drug. But a new dose taken at this point will relieve all his symptoms, though this relief will inevitably be followed by a recurrence of them, to be similarly relieved. Now, this cycle of symptoms is much more extreme than one could reasonably explain on the mere theory of reaction in the nervous system. If a victim of the morphia habit be suddenly deprived of his drug entirely, he will not only be miserable, but will exhibit all the well-marked physical signs of very grave and dangerous prostration. In short, the patient looks as if he were poisoned—*actively poisoned*, not merely suffering from the loss of an accustomed stimulant. Furthermore, as time goes on, a whole series of changes occur in his body, and these are not changes which tally with the known properties of morphine. Now, in all probability these results are due to an oxidation product of morphine which is known as *oxy-di-morphine*. This is formed in the body itself by a very simple change in the molecule of morphine, and it illustrates once again the remarkable fashion in which a slight change in the molecule of an alkaloid may reverse its chemical properties in contact with living matter.

A Problem for Chemistry. From this discovery it follows that the larger the amount of morphine taken the greater is the amount of oxy-di-morphine which is produced and causes the subsequent symptoms; hence, suddenly to cut off the supply of morphia is suddenly to leave the patient under the unantagonised influence of its derivative, which may be so powerful as to threaten death. Already the recognition of these facts has led to great improvement in the treatment of these cases, which are daily becoming more common. It probably remains for organic chemistry to provide us with some substance which will precisely destroy or neutralise the oxy-di-morphine. To do so would be to cure the habit. These wretched patients must not be conceived of as deliberately doing what will hurt them. On the contrary, the craving must be regarded as the demand of the body for some substance which will neutralise the appallingly distressing action of the poison which is circulating in the patient's blood. The whole existence of the evil is due to the fact that the substance which is demanded and taken in order to neutralise the effects of this poison is itself the source of a fresh supply. Obviously, here is a practical problem which awaits its solution by the higher chemistry, and which that chemistry will certainly solve one day.

The Essential Ingredient of Tea and Coffee. After morphine, *caffeine* may, perhaps, be regarded as the most interesting of the alkaloids. It is of very great interest, in the first place because of its chemical relations, secondly, because of its remarkable properties, and thirdly, because of its extremely extensive use by mankind—a use more extensive even than that of opium or possibly alcohol. This alkaloid is the essential ingredient of tea and coffee. The name *theine* used to be applied to it when it was derived from tea, but it is one and the same substance in both cases. In this country we actually drink about four million gallons of tea every day, and the one and only ingredient which determines this enormous use of the plant is its *caffeine*. The percentage of the alkaloid in a typical leaf may be from nearly three to just over four per cent. The proportion of it in Indian and Ceylon teas is slightly higher than in China teas. Whether the tea be properly or improperly made [see page 3822], practically all the caffeine in the leaf enters the infusion. An ordinary cup of tea contains about a grain of caffeine.

Caffeine is also the substance on account of which men drink coffee. The proportion of caffeine in coffee, after roasting, is about 1 per cent. The roasting involves the loss of about one-fifth of the caffeine originally contained in the leaf. If the leaf be over-roasted much more caffeine is lost. Neither the taste nor the flavour of coffee or tea depends upon the essential ingredient. An ordinary cup of coffee does not contain appreciably more caffeine than an ordinary cup of tea, despite the common notion that it is much less harmful to drink tea than coffee. People who are upset by coffee and not by tea are usually affected not by the alkaloid, but by the volatile oil known as *caffeol*, which is formed in the bean during the process of roasting, and to which the aroma of coffee is due.

Now, cocoa contains no *caffeine*, but, in place of it, an alkaloid which is very closely allied to caffeine, as we shall shortly see, and is known as *theobromine*—from Greek *theobroma*, food of the gods, the botanical name for cocoa. The proportion of theobromine in cocoa is about the same as that of caffeine in tea and coffee.

What Caffeine is. The empirical formula of caffeine—which we may note is the essential ingredient not only of coffee and tea but also of Paraguay tea, or maté, and of the

beverages made from kola nut and of the substance called *guarana*—is $C_8H_{10}N_4O_2$, but this empirical formula, like most of its kind, is extremely uninstructive. Chemically, however, caffeine is a product of a very well known and important body known as *xanthin*. This has the formula $C_5H_4N_4O_2$. Now, if the reader will recall the formula of uric acid, the simplest statement of which is $C_5H_4N_4O_3$, he will see that uric acid may be regarded as an oxidation product of xanthin. In point of fact, xanthin represents a very important stage in the series of chemical changes by which the body-substances known as *nucleo-proteids* break down into uric acid.

Now, theobromine is none other than di-methyl-xanthin, while caffeine may be called either *methyl-theobromine* or *tri-methyl-xanthin*.

Effect of Caffeine in the System. These facts give us some key to the manner in which we may conceive caffeine and theobromine to be produced by the numerous plants in which they are to be found. Plainly, they must be derived in the course of the breaking down of the nucleo-proteids which are found in those plants, as in all other living things. But the relations of these alkaloids are of even greater practical importance, because it is generally supposed that when they are taken into the body they become sources of uric acid like xanthin itself. Now, since the excessive presence of uric acid in the body is characteristic of gout and various other diseases, many people have joined in a crusade upon all articles of diet that yield uric acid. This crusade furnishes a very good instance of bad reasoning in matters of science. It is argued that because uric acid is found to be produced in excess in gout, any article of diet which produces uric acid in the body will itself tend to favour the production of gout. When we consider the matter we see that this does not follow in the least. The essence of gout is not the production of uric acid but a disordered cell chemistry which, as it happens, leads to the production of uric acid as one of its symptoms or indications. Unless it can be shown that tea, coffee and cocoa, for instance, lead to the production of this morbid cell chemistry, nothing can be alleged as to their supposed malign action. It is ludicrous logic to argue that because caffeine or tri-methyl-xanthin is a source of uric acid, it is therefore capable of disordering the cell life of the body in such a fashion as to make the contents of the cells themselves yield uric acid. Thus, the logic of the argument is worthless. Still more amusing is the quite recent research (communicated to the Paris Academy of Sciences on June 18th, 1906), which shows that caffeine and theobromine do not yield uric acid at all in the body, but leave the body in the form of more complex substances, against which no evil action has been alleged.

The Chemistry of Consciousness. Both the facts and the logic of this doctrine having been refuted, let us summarise, as briefly as possible, the main facts of this compound tri-methyl-xanthin, of which mankind daily consumes such gigantic quantities. The first noteworthy fact is that, unlike alcohol and opium, caffeine is a true stimulant. An increased rapidity of the vital functions is not merely, as in these other cases, a preliminary to retardation of them, but constitutes the essential action of the drug. It is not then, a pseudo-stimulant but a true stimulant. Furthermore, its stimulation extends from the lowest to the highest tissues. So far as is known the drug is unique in that it stimulates the highest functions of the brain. In certain persons morphine stimulates the imagination; everyone knows that Coleridge wrote a wonderful poem under the influence of morphine. But morphine does not stimulate the reasoning powers; caffeine, on the other hand, definitely does. There is no other drug which, like caffeine, has the remarkable property of preventing sleep, purely by its immediate action upon the brain. What exactly is the part that this alkaloid plays in the chemistry of consciousness, preventing those changes which result in sleep, no one yet knows. But the chemistry of consciousness is incomparably the most interesting and important problem of all chemistry; and it is an extremely interesting fact in this connection that tri-methyl-xanthin, itself so closely allied to a degradation product of the substances which are characteristic of the nuclei of living cells, should have this remarkable effect upon the functions of the most wonderful living cells which we know or which we can conceive.

The Great Value of Tea and Coffee. Caffeine not only keeps one awake, and is not only vastly superior to any other known substance as a stimulant for any special intellectual exertion, but its stimulation on the brain is even and balanced, and has no subsequent reaction. The caffeine yields no product that antagonises its own actions as morphine yields oxy-di-morphine.

We submit these very brief statements to the reader, and will ask him to observe the noteworthy fact that this alkaloid, beverages containing which have become practically a necessity of human life wherever and whenever they have been introduced to a people, stands the test of critical scientific investigation in a manner which explains its well-earned popularity. We are far from saying that tea and coffee are not capable of abuse, like most other or all other good things. But we will insist that chemistry has done a great service in enabling us to analyse these beverages and to distinguish between the actions of their various ingredients. The result of the inquiry is to show that of the injury which these beverages do—an injury which is quite trivial when compared with the sum of their value to men—at the very least nine-tenths must be attributed either to the tannic acid which tea and coffee both contain, or to the powerful caffeol contained in coffee, and not to the alkaloid, unique in its combination of potency and all but innocence, to which these beverages owe their popularity.

Caffeine crystallises out from aqueous solutions in light, silky, colourless crystals

having one molecule of water of crystallisation. It is soluble only to the extent of 1 part in 80 in cold water. At the temperature of boiling water it melts, and then volatilises. It can be obtained quite readily from a cup of tea by treatment with an alkali and chloroform, in which it is highly soluble. Like other alkaloids, it forms salts, but these are very unstable. The most convenient of them, and one which is more largely employed every day, is the citrate, prepared by adding caffeine to a hot solution of citric acid and evaporating. This is very much more soluble than the alkaloid itself, and has the same properties.

True and "False" Stimulants. No better proof of the stupid way in which the word *stimulant* is used, even in scientific writing, can be furnished than the contrast between alcohol and caffeine. Alcohol is a sedative which has a period of preliminary stimulation. The ultimate explanation of its sedative action doubtless depends upon its interference with oxidation, which is the source of all the energy of the body. As we have already seen, alcohol retards the vital processes by increasing the stability of oxy-hæmoglobin. In none but a superficial sense, then, is it a stimulant. A drug which interferes with oxidation and lowers the temperature is essentially the reverse of a stimulant. On the other hand, caffeine, which is a pre-eminent example of a true stimulant, has been proved to increase the oxidation of the body, as is evidenced by the increase in the amount of urea which is produced under its influence; and, furthermore, in considerable doses, caffeine raises the temperature of the body—this rise having been shown to be due not to any interference with the loss of heat by the surface of the body, but to the increased production of heat consequent upon the more rapid oxidation which is caused by the drug.

If the word stimulant is to be retained, either in scientific or popular language, it is highly desirable that it should be used so as to mean something, and not so as to darken counsel by words without knowledge. The present writer has already, in the scientific journals, insisted upon the need for an intelligent use of the word stimulant, and he here submits to the reader the proposition that any substance which, like caffeine, increases the amount of oxidation in the body is fundamentally a stimulant, while any drug that does the reverse is fundamentally a sedative, oxidation being the very source and essence and condition of vital activity. Some such opinions as these are now steadily gaining ground. They furnish a good illustration of the general proposition that in all matters of the living body the analysis of phenomena is imperfect, and will only too probably be misleading, *until it has reached the chemical stage.*

Atropine. The next important alkaloid that we must consider is called *atropine*, being the characteristic alkaloid of the natural order of plants known as the *Atropaceæ*, or sometimes as the *Solanaceæ*. Its chief source is the "deadly nightshade," the botanical name of which is *Atropa belladonna.*

Atropos, the reader may remember, was the eldest of the Three Fates. She held the "abhorred shears," and it was her function to cut the thread of life. Keeping this in mind, the reader will be able to co-ordinate his knowledge, as knowledge should be co-ordinated in every well-made mind, so that Greek mythology, botany, an immortal English poem, chemistry, and toxicology—the science of poisons—may each suggest the other.

The first point worthy of note is that there is a whole series of plants, belonging to the same natural order, which yield atropine. Not so long ago different names were applied to the alkaloid according as it was derived from, for instance, the deadly nightshade or the thorn-apple; but the alkaloid is one and the same in each case, and it is infinitely better to use the same name for it. The reader will not fail to observe the significance of the fact that a series of plants which resemble one another in their external characters sufficiently to be classed in one order by botanists, also resemble one another so closely in their internal vital chemistry that they each yield the same substance.

The Standardisation of Drugs. Atropine occurs both in the roots and the leaves of the deadly nightshade, the percentage in the latter —about 0·4—being the more constant. The time has finally passed, however, when we can permit ourselves to make tinctures, extracts, and so on, of leaves and roots, and trust to chance for the proportion of the alkaloid that these preparations may contain. Either the alkaloid itself must be employed for medical purposes, or else these preparations must be standardised. This is now the rule; at any rate, to the extent that the tincture of belladonna, for instance, in this country, is standardised so that it must contain 0·5 per cent. of the total alkaloids of the root. Other alkaloids occur in belladonna.

These are very closely allied in molecular structure to atropine, and are also found in other plants belonging to the same natural order. The empirical formula of atropine is $C_{17}H_{23}NO_3$, and it occurs in the belladonna plant in the form of a malate or salt of malic acid. It is dissolved out from the leaves or root by means of chloroform, and can be obtained in colourless crystalline needles. It can be decomposed into a somewhat simpler body called *tropine*, and an acid called *tropic acid*. This is important, because tropine can be used as a source of other artificial alkaloids, one at least of which, called *homatropine*, is very useful. It has also to be remembered that if drugs containing atropine be mixed with alkalies, the alkaloid is decomposed into tropine and tropic acid, which are of no value. The belladonna plant also yields another alkaloid, which is known as *hyoscyamine*, since it is more especially characteristic of the henbane plant or *Hyoscyamus niger*. The two alkaloids have the same empirical formula, but differ in the structure of the molecule, the difference being indicated by the melting point, the optical properties, and the action upon the body. They seem capable of ready conversion one into the other.

A Remarkable Influence upon Nerves. We must not here discuss at length the physiological properties of this extraordinary alkaloid, which has the most marked action upon nearly all the functions of the body, even when it is administered in doses of one-hundredth of a grain, and one five-thousandth part of a grain of which is quite sufficient, when used by the oculist, to dilate the pupil of the eye for many hours. In general, it may be said that atropine paralyses the terminal part—not the trunk—of all those nerves of the body the business of which is to stimulate involuntary muscular tissue, and also the terminals of all the nerves that stimulate glands to pour forth their secretions; hence the dryness of the mouth in cases of belladonna poisoning. We need scarcely comment upon the extraordinary significance of this selective action of the drug, which proves that the chemistry, or the physical chemistry, of the extreme tips of these peculiar kinds of nerves is utterly distinct from that of the ordinary motor nerves that supply voluntary muscular tissue, such as the muscles of the limbs. Atropine is an extremely valuable drug in medicine, and is the essential ingredient of nearly all the drugs that are given in asthma, whether these are patented or unpatented.

The Mysterious Power of Hyoscine. We can say no more here about hyoscyamine, but henbane also contains a remarkable alkaloid known as *hyoscine*, which is very closely allied to atropine and hyoscyamine, and has the formula $C_{17}H_{21}NO_4$. This drug is of unique interest in relation to the chemistry of consciousness. The comparatively trivial difference in its molecular constitution suffices to endow it with properties not only totally distinct from those of its allies, but also unique in character and potency. It may be said that even in cases of the most violent maniacal excitement of the brain, one-hundredth part of a grain of this alkaloid injected under the skin, anywhere, will arrest consciousness and cause sleep within sixty seconds. Neither morphine nor hydrocyanic acid, nor any other known body, can remotely approach hyoscine in its power of arresting what are, of course, incomparably the most marvellous and incomprehensible of all chemical processes—those with which consciousness is associated. Here we simply state the facts; no explanation of them can be suggested, but the significant thing for those who look ahead is that it is from such indisputable facts as these that the science of the future will be enabled to elucidate the greatest problems of chemistry—those associated with life and consciousness.

Tobacco. The tobacco plant belongs to the same natural order—the Solanaceæ or Atropaceæ—as the deadly nightshade and the henbane, and it also yields an extremely potent alkaloid, *nicotine*. Nicotine, however, differs very markedly from atropine, for instance, in its relations to the chemistry of life, and this we may associate with the fact that nicotine differs notably from the great majority of the alkaloids in that it contains no oxygen. Its empirical formula is $C_{10}H_{14}N_2$, and it is also noteworthy as being a liquid alkaloid. It occurs in the tobacco leaf in proportions varying between 2 and 8 per cent. The alkaloid is an oily, volatile, colourless liquid. Unlike most alkaloids, it is readily soluble in water. It resembles other alkaloids in being extremely soluble in alcohol and ether. It is a very powerful antiseptic. The alkaloid itself is one of the most horrible and potent of poisons.

Nicotine a Deadly Poison. A dose of nicotine will kill in a few minutes, even when taken by the mouth. The extreme rapidity of its action doubtless depends upon its volatility. It is probably poisonous to every kind of tissue, and it alters the hæmoglobin of the red blood corpuscles, as is proved by the modification which it causes in the spectrum of blood on which it has acted. In many respects nicotine contrasts very markedly with the typical action of the alkaloids of the natural order to which it belongs. It has extremely slight effects, if any, upon the chemistry of consciousness. This fact is of considerable interest in relation to the practice of smoking. Nicotine is never used in medicine, though before the discovery of the anæsthetic properties of ether, chloroform, and nitrous oxide, tobacco was occasionally used, so that, by poisoning the motor nerves, and relaxing the muscles, it would permit the surgeon to reduce a dislocation. Any smoker who remembers the early effects of tobacco poisoning will appreciate the superiority of modern anæsthetics over this alkaloid, which was of value simply because it made the patient miserably weak.

The Chemistry of Tobacco Smoking. Smokers often describe as nicotine the oily mess which is apt to accumulate in a pipe, and of which they sometimes get a mouthful. If this, or 1 per cent of it, consisted of nicotine, one such mouthful would end the smoker's career. As a matter of fact, nicotine is not merely oxidisable, as its physical characters and its formula would suggest, but is so at relatively low temperatures. The whole of the nicotine in the portion of tobacco that is undergoing combustion at any given moment is oxidised away. Probably, also, nearly the whole of the nicotine in the portion of tobacco that is immediately about to undergo combustion undergoes decomposition. It has therefore been asserted, in all probability much too hastily, that tobacco smoke contains no nicotine. If this were so, it would certainly be remarkable that the symptoms of poisoning by it so strikingly resemble those of poisoning by nicotine.

How Nicotine Enters the System. As a matter of fact, tobacco (smoke) *does* contain nicotine, which is volatilised from the tobacco that is so remote from the part undergoing combustion as not to undergo decomposition but is yet near enough to acquire an amount of heat that suffices to volatilise it. In this gaseous form, then, the alkaloid is taken in by the smoker. The portion of it in tobacco smoke is, of course, exceedingly small, as the possibility of smoking without fatal results proves, but it is nevertheless sufficient, the alkaloid

being extremely potent, to cause very definite physiological effects. These vary considerably with varying conditions. As in the case of most other poisons, the body can acquire a relative immunity from its effects. Again, different individuals vary in their susceptibility to it, so that some can never smoke, while others cannot smoke a pipe, or can only smoke very mild tobacco in a pipe.

Inhaling Tobacco Smoke. Furthermore, the effects of the poison must obviously depend, other things being equal, on the actual quantity of it that enters the blood, and this depends upon the amount of absorbing surface which is exposed to the smoke. There is a very marked difference indeed between the amount of nicotine absorbed from the mouth and that absorbed by the lungs. This is the reason why the practice of inhaling the smoke of cigarettes is so extremely undesirable. Different tobaccos vary very widely indeed in the proportion of nicotine which they contain. There is exceedingly little in Turkish tobacco.

This fact alone shows how completely smokers —who really ought to have some acquaintance with the chemistry of the subject—are misled. The nicotine in tobacco smoke determines its strength alone. It has no influence upon its flavour or aroma. These are mainly due to an essential oil. Any smoker will say that a Turkish or Egyptian cigarette is "stronger" than a Virginian cigarette, but, as a matter of fact, the former contains very much less nicotine—though it doubtless contains more of the essential oil, and of various other imperfectly investigated —not to say artificially added—compounds which may themselves have very marked properties.

We can merely note a few of the substances which are usually found in tobacco smoke; nearly all are constantly present. They are nicotine, hydrocyanic or prussic acid, sulphuretted hydrogen, nitrates, nitrites, carbolic acid, various compounds of ammonia, of sodium and of potassium, salts of acetic and other acids, creosote, sulphur, a volatile fatty acid, together with a considerable percentage of pyridin and several of its allies.

Smoking Should not Begin till 21. We desire to emphasise the definite fact that nicotine, not to mention various other substances found in tobacco smoke, is essentially, fundamentally, characteristically a poison. This statement holds good, and is not affected by the fact that, as in the case of arsenic and a hundred others, the adult organism is capable of acquiring an immunity from its action, and thereafter may obtain from it advantages of one kind and another. But if the reader will consider the question of growth in living things from the standpoint of chemistry, and will try to realise the exceptional and peculiar complexity and delicacy of the chemical processes which are involved in growth, and incomparably more so in *development*—which is an infinitely more subtle thing than increase in bulk—he will be prepared to accept the general proposition that, in the first place, the adjustment to the constant introduction of a poison, which is possible at a very small cost, for the relatively stable adult organism must involve far more serious modifications in the vital chemistry of the developing organism; in short, that a poison which may be tolerable for the man will be intolerable for the child, even if the dose be diminished in proportion to the ratio between their body weights. In naming the age at which the use of tobacco may be excused, most authorities are more or less influenced by the actual facts as to the age at which boys begin to smoke. The general proposition is that the use of such a substance should be begun, if at all, only after the developmental period has passed; and when Sir William Broadbent named the age of 21 as the minimum he was undoubtedly nearer the truth than those who—looking more upon the mere expediency of the matter—name such an age as sixteen. At any rate, it is a perfectly outrageous thing that irresponsible urchins of a dozen years should ever be permitted to injure themselves by the absorption of this poisonous alkaloid.

The Alkaloid of Hemlock. From the spotted hemlock, or *Conium maculatum* (Nat. Ord. *Umbelliferæ*), there is obtained an alkaloid known as *conine*, which may be considered here, since, like nicotine, it is liquid, oily and volatile, and also since many of its physiological properties are similar to those of nicotine. Its empirical formula is $C_8H_{16}HN$. This body is of a yellowish colour, has an odour which is usually described as "mouse-like," and its taste suggests tobacco. It can be obtained readily from the fruit or the leaves of the hemlock by distillation with alkalies. Conine is extremely unstable, being readily decomposed, both by light and heat. Furthermore, the proportion of it present in the plant varies widely. Its methyl derivative, known as *methyl-conine*, also liquid, is found associated with it in the hemlock plant. All the preparations of hemlock prepared for medical purposes are to be condemned by a more advanced chemistry, since they are not standardised, and since the proportion of conine in them is quite inconstant. A classic and tragic interest attaches to the symptoms of poisoning by conine. An account of them, scarcely less precise and accurate than any that could be written to-day, when conine has been isolated from the plant and studied in detail, is to be found in the greatest of the dialogues of Plato, known as the *Phaedo*. At the end of this great dialogue there is described the death of Socrates, one of the supreme immortals of all ages, whom his Athenian fellow-citizens condemned to death by hemlock.

Strychnine. The plant known as the *Strychnos nux vomica* contains a remarkable alkaloid known as *strychnine*, which occurs in the nut to the extent of 0·2 to 0·6 per cent. In this country preparations of nux vomica are now standardised so as to contain precise quantities of strychnine. The alkaloid has the formula $C_{21}H_{22}N_2O_2$, and can be obtained in the form of small colourless crystals. It is remarkable as the bitterest of all known substances, being able to cause in the nerves of

taste those chemical changes which lead to their stimulation, even in the dilution of one part in thirty thousand. It is extremely insoluble even in hot water, but is soluble to the extent of one part in six of chloroform. This dangerous alkaloid must never be prescribed with alkalies, iodides or bromides, for these precipitate it, so that, while the early doses taken from the bottle are of no value at all, the last may be fatal. Strychnine unites with hydrochloric acid in similar fashion to that of ammonia, yielding a fairly soluble salt, of which as much as one-fifteenth of a grain may be taken by an adult with safety. Allusion has already been made to the most important of the remarkable properties of this alkaloid. It constitutes, perhaps, the most appalling of poisons, since it has no action on consciousness whatever. The treatment of strychnine or nux vomica poisoning is an urgent matter. Any alkaloid that remains in the stomach may be precipitated by tannin or charcoal, or oxidised by permanganate of potassium. A large number of other antidotes have been tried, but there seems to be no doubt that the best hope for the patient lies in the administration of chloroform, which arrests the convulsions that would otherwise lead to the patient's agonised death from exhaustion.

Alkaloids of Aconite. We may briefly allude to the alkaloids contained in various kinds of aconite plant, since, though this drug has fallen into deserved disrepute in these days, its principal alkaloid, *aconitine*, is of interest as one of the most powerful of all poisons. It has the formula $C_{33}H_{43}NO_{12}$, and is accompanied in the plant by several other alkaloids which are closely allied to it. One of these is called *aconine*, and can be prepared artificially by heating aconitine in the presence of water, of which it takes up one molecule, then yielding aconine and benzoic acid. A plant belonging to this genus and known as the *aconitum ferox* contains an alkaloid, *pseudo-aconitine*, which is the most poisonous of all known substances. About one-three-hundredth part of a grain would probably kill a man. Apart from such curiosities the root of the aconite plant may be regarded as the most powerful of all non-volatile poisons.

Quinine. The last alkaloid which we need consider is the most valuable of all with the exception of morphine. It is contained, together with four other closely allied alkaloids, in the bark of the red cinchona—*Cinchona succirubra.* This beneficent plant grows in South America, and was wisely introduced into India many years ago by Sir Clements Markham.

The empirical formula of quinine is $C_{20}H_{24}N_2O_2$. It is found in the bark in the form of its hydrate. It can be obtained in the form of bitter, colourless, needle-shaped crystals, which rotate the plane of a ray of polarised light to the left. Solutions of the oxy-salts—not of the chloride, for instance—of quinine are fluorescent. (The meaning of both of these statements will be intelligible to the student of the course on Physics.) *Quinidine*, an isomer of quinine, also occurs in the cinchona. Its most important distinction from quinine is that it is dextro-rotatory. Two other alkaloids, differing only from these in containing one atom of oxygen instead of two in the molecule, are also found in the plant. Of this second pair of isomers one is dextro- and the other lævo-rotatory. Preparations of cinchona bark, now very rarely used, are standardised in this country as to their percentage of total alkaloids.

Quinine is used in the form of one or other of its salts. The salt chosen is almost invariably the sulphate, which, however, is soluble only to the extent of one part in eight hundred of water, and is quite insoluble in alkalies. From these considerations it follows that when this salt is administered the patient benefits only by such a small proportion of it as can be absorbed before the salt reaches the first part of the bowel, the reaction of the contents of which is invariably alkaline. The truth is that the sulphate is used perhaps more because it was the form in which quinine was first discovered, and so had a long start, than for any other reason. A salt vastly superior is the hydrochloride, which has one molecule of hydrochloric acid to each molecule of quinine; and still better is the acid hydrochloride, which has two molecules attached to each of the alkaloid. This last is soluble in less than its own weight of water.

Quinine and Vital Chemistry. Since quinine is the one known specific against malaria—the disease which causes more illness, though tuberculosis causes more deaths, than any other—its properties in relation to living matter are necessarily of the first interest. Needless to say, they have been studied with the utmost care, though even yet there is much to learn. We may say, however, that quinine appears to be one of those substances which in some degree or other directly interfere with the processes of vital chemistry. This is as good as to say that it is an antiseptic. Malaria is now known to be due to the presence in the blood of minute parasites, and the value of quinine depends upon the fact that it directly kills these organisms. Students of the problem of impregnating the blood with an antiseptic know how all but impossible this is to effect, except at the cost of life itself. We have already seen, in the case of carbolic acid, the typical antiseptic, that the acid is altered into an inert sulpho-carbolate, and can exist as an antiseptic in the blood only at the cost of life. Quinine, however, though by no means a powerful antiseptic, can exist in the blood as quinine. It is well worthy of note, as proving the fundamental identity of vital chemistry in various forms of life, that quinine paralyses not only the malaria parasite, but also the white cells of the blood. Doubtless many of these are killed by it, but fortunately the body can replace them, while the malaria parasites, when killed, cannot be replaced.

Quinine and Alcohol in the Body. One other point is well worth noting for its significance.

In the case of alcohol we saw that one and the

same substance both arrests the movements of the white blood corpuscles, and interferes with the decomposition of the oxy-hæmoglobin of the red blood corpuscles. Now, the same is precisely true of quinine and of some other substances. We naturally seek, then, for some reason which will furnish an explanation of what would otherwise look like a curious coincidence. The suggestion which may be here made is one dependent upon a consideration of the causes of motion in living things. The student of physics and of the doctrine of the conservation of energy is well aware that a white blood cell, like a bullet or a star, cannot display energy of motion, or kinetic energy, except in virtue of the transformation of pre-existing energy. Now, the source of energy in the case of the white cell—and this is true of the whole or all but the whole of the energy displayed in any living thing whatever, whether an oak or a man or a microscopic cell in the man's blood—is the potential chemical energy which is liberated in the act of oxidation. Now, it would appear reasonable to infer that the reason why alcohol, quinine, and other substances which interfere with the reduction of oxy-hæmoglobin also interfere with the motion of the white cells is that these substances similarly interfere with the reduction of compounds comparable to oxy-hæmoglobin, which must be present in the white cell as in every living cell, and which are its storers of oxygen; for the oxidation of protoplasm, as we saw long ago, is not only intracellular but even intra-molecular.

Quinine and Oxidation. Two further facts may be correlated with the theory which we have suggested. One is that the amount of uric acid excreted by the body after the administration of quinine is greatly diminished. Now, uric acid, as we have already seen, is an oxidation product of the particular kinds of proteids which are found in the nuclei of living cells, and are called *nucleo-proteids*. White blood cells practically consist of little more than nuclei, and are a most important source of uric acid, for when their numbers are greatly increased, as they are in certain diseases, the amount of uric acid excreted is also increased. Similarly, in this case we see that the amount of uric acid excreted is diminished when the amount of oxidation in the leucocyte is diminished.

The second fact is that quinine interferes with the process of oxidation in many other kinds of living matter, in addition, as we suspect, to white blood cells. The absorption of oxygen by various fungi is interfered with under the influence of quinine, and various lowly vegetable organisms which normally display phosphorescence—known to be due to rapid oxidation—cease to display this property when they are subjected to the action of quinine.

Why quinine should interfere with oxidation is as yet quite beyond the power of chemistry to say; but it is a step thereto to have included under this one proposition—interference with oxidation—so many and apparently diverse properties of this substance.

There are two important groups of compounds which are related to the alkaloids, but are, nevertheless, quite distinct from them. The first of these go by the name of *neutral principles*. They are not *alkaloids* because they are not basic, but neutral, and they are not *glucosides* because they do not yield glucose, but they are related to both these groups of substances, and many of them are extremely potent drugs. Typical of them is the body known as *aloin*, which is the active principle of *aloes*, the valuable purgative, and by selling which at a price a few hundred times too high to persons, all of whom are ignorant and to many of whom a shilling is a serious matter, most of the patent medicine manufacturers derive their monstrous incomes.

Glucosides. More important are the *glucosides*. They have long been known to be of the utmost interest because several members of this group are amongst the most potent of drugs. But we shall also see that quite recently—indeed, within the present year—a new interest has come to attach to the glucosides in general because of the part which they are believed to play in the body. Glucosides may be defined as complex organic substances which are compounds of glucose. Until quite recently they were supposed to be confined to plants. They are crystalline. When hydrolysed by various agencies, such as certain acids and alkalies, or by means of such a ferment as the emulsin found in the almond, they yield glucose and some other substance, most commonly an alcohol, an aldehyde, or a phenol. We have already alluded to an example of a glucoside in salicin. In this, and in all other cases, the name of the body must be spelt with a terminal *-in*, thus distinguishing it from the alkaloids, the names of which are marked by a final *e*.

The Most Valuable Heart Tonic. The glucoside *salicin*, though exceedingly valuable, is not often employed in medicine now, because sodium salicylate is more convenient. But it may be noted that the most valuable stimulants which are employed as favourable to the health of the heart are glucosides. The leaves of the common purple foxglove (*Digitalis purpurea*) have long been in use as by far the most valuable of all known heart tonics. Of recent years they have been very carefully studied, with results which significantly resemble those obtained in the case of many other plants—that is to say, the recognition of the presence within the plant of substances whose molecular construction is all but identical, but which, nevertheless, exercise upon the body properties diametrically opposed to one another. We have already striven to make it plain to the reader that there would be relatively little interest for us, as chemists, in the mere fact that molecules, slightly different, exercise different properties. This we should expect. The significant thing is that the properties are not merely different, but directly antagonistic, and this is found to occur again and again in the case both of alkaloids and of glucosides.

The Chemistry of the Foxglove. The leaf of the foxglove contains four glucosides, very closely allied; possibly there may be more. It contains no alkaloids whatever. Of these glucosides, one (which is identical with a glucoside found in other plants, such as the senega plant of the New World) is a powerful poison to the muscular tissue of the heart, and thus directly opposes the action of its neighbours and relatives. Obviously, then, as soon as it is possible to obtain the valuable glucoside without the worse than worthless one, the use of crude preparations of the leaves must be superseded.

The one serious rival of the foxglove as a heart tonic is the seed of the strophanthus plant, used as an arrow poison by the natives of West Africa. The cotyledons of the seed may actually contain as much as 50 per cent. of an extremely powerful glucoside called *strophanthin.* This extraordinary substance (the function of which in the plant is entirely unknown) has a unique chemical relation with the muscular tissue of the heart. This markedly differs from its relation to muscular tissue elsewhere, and is true alike of the heart of man, the highest of mammals, or of the heart of the frog, which is a mere amphibian.

A Remarkable Identity. The reader will ponder upon the necessary inference that there is a chemical identity in heart muscle wherever found. This glucoside, and the same is true of many other substances, proves that the chemical relationship between the heart muscle of a man and the heart muscle of a frog is actually nearer than that between the heart muscle of a man and the muscular tissue of the midriff or diaphragm on which that heart rests. To the best of the writer's knowledge the significance of these facts has never hitherto been insisted upon, but it is surely evident enough, once considered. A solution of one part of strophanthin in ten millions will so violently stimulate the muscular tissue of the heart of a frog as to arrest it in a state of continuous spasm.

New interest has lately been attached to the glucosides by experiments which seem to show that the glucose that is found in human blood, and that represents the form assumed, as the result of digestion, by all carbohydrates, does not exist in the blood as such but as a glucoside. The fact seems to be that uncombined glucose would be treated as a foreign body in the blood, and would promptly be removed from it. Existing as a glucoside, however, the glucose may remain, and when it is needed by the muscles, which find in it a source of the potential energy which they transform into work, the glucose can readily be obtained from the glucoside by means of hydrolysis, under the influence of one or other of the body ferments. We have already seen that plants contain ferments capable of effecting this decomposition.

Chemistry of Plants and Animals. Special interest attaches to these researches because they afford one more illustration of synthetic power within the animal body—the synthesis in this case being that involved in building up into a glucoside the glucose which the blood derives from the bowel. It used to be stated positively that the fundamental distinction between the chemistry of the plant and the chemistry of the animal is that synthesis—as in the making of proteids and carbohydrates—is peculiar to the plant alone. All the chemistry of the animal body, or practically all of it, was supposed to be analytic. The animal body could merely break down the compounds which had been built up by the plant. In general, this great distinction is undoubtedly true, and is absolutely fundamental to our conception of the chemical balance between the various kinds of living things.

But it is of great interest to know that there are not a few cases in which the animal body is capable of effecting synthesis for itself. A more accurate manner of expressing the distinction will have to be found, and perhaps we may find it here. The animal body may build up glucose into a glucoside for its own convenience; but, both in the case of the glucose and of the other compound with which the glucose is combined to form the glucoside, the animal body is first dependent upon the synthetic power of the plant.

"No Sun, no Shakespeare." Now, the plant is dependent upon nothing at all. The very elements suffice for it. On the other hand, whatever synthetic powers the animal body may yet be shown to possess, we may take it as certain that it is absolutely destitute of any power of building up compounds *from elements.* The blood of every animal contains a large proportion of elemental nitrogen, but nothing ever comes of it. The lungs of every civilised person contain large quantities of elemental carbon, but nothing ever comes of it. Elemental phosphorus may be administered to an animal, but though phosphorus is a necessary constituent of living matter, nothing ever comes of it. The necessary nucleo-proteids—containing phosphorus—of the animal cell, it owes one and all to the synthetic activity of the vegetable cell. The world of life is so wholly one that, in the natural order, we may say *No green leaf, no Goethe*; just as we may say, *No sun, no Shakespeare.*

Continued

MAKING BOOTS AND SHOES

Measuring the Feet. Cutting, Skiving, Sewing, Stitching. Making the Thread. Machine Sewing. Buttoned and Elastic-sides Boots

BOOTS AND SHOES continued from page 3877

By W. S. MURPHY

BADLY FITTED boots are extremely annoying to the wearer, and sometimes dangerous. If the fashionable shape fits no human foot, the fault lies with the customer who chooses to wear—for the vanity of appearing fashionable—a boot that injures the foot. But let not the shoemaker whose customers complain lay that flattery to his mind too much; he, and not fashion, may be to blame. The first condition of comfortable boots is accurate measurement. Feet vary as much as individuals; you will never see two persons with feet exactly alike, and there are even differences between the right and left foot of the same person. In the ready-made trade we have got over the difficulty presented by these facts by a careful gradation of sizes and classes of boots, which shall be explained in due time; but every hand-made boot is formed for the foot of the customer by whom it is ordered. Actual measurement is the obvious way of arriving at the proper sizes of the boots to be made. Simple as the proposition appears, many shoemakers ignore it one way or another. To spare the customer trouble, the length of the foot and the height from heel to front of the instep are taken, and the rest worked out to a scale of averages. Both from a technical and a business point of view, this is a mistake. Customers like to feel that we are taking trouble with them, and doing our best to please. If it is done in a polite manner, additional bother gratifies a customer.

Outlines of the Feet. An outline of the soles of the customer's feet is very useful. To obtain this, lay a piece of paper on the floor, and ask the customer to stand on it. Carefully go round the foot with a pencil held perfectly upright, and trace its outline, marking the *positions* on this tracing where all the cross-measurements are taken. [See page 1330.]

The Measurer. The measurer should use two standards, the size-stick [29 H, page 3879] and the tape. A size-stick is a thick foot-rule with a fixed block at one end for the heel to rest against, and at the other end a sliding block that comes up to touch the toe of the foot. The stick is marked with inches, divided into sixteenths, and the boot sizes divided into halves. Let the two blocks gently enclose the foot from heel to toe, and mark down the number indicated.

Method of Measuring. The diagram on page 1330 illustrates the best method of taking measurements. On the foot itself we have three dimensions corresponding to the main features in its structure. The tape marked "joint" indicates the direction of measurement across the joint. In a properly formed foot the toes are not in line, and the tape must be slanted round the foot, and the exact angle registered on the tracing. The rule is to take the root joints of the large and small toes and to draw the tape neatly round. Mark down the number of inches and fractions. Put the tape round the foot at the instep, as shown on the diagram. This is meant to show the thickness of the foot round the centre of the instep arch. Mark that measurement down, and then shift the tape to the heel, or bend of the foot. The tape marked "ankle" shows the direction in which the measurement should lie.

30. CLICKING, OR CUTTING OUT UPPERS

Accuracy. It is of prime importance that this measure should be accurately taken. For button boots especially, the size from heel to front determines a great deal; if too slack or too tight at that point, the symmetry of the whole boot is lost. Discomfort can be avoided by simply sewing on the buttons according to the width required, or lacing the boot slackly; but though comfort is assured, the boot remains a botch. For men's boots, one "leg" measurement only is usually taken. The point of measurement is at the slenderest part of the leg, about 2 in. above the ankle-bone, as shown on the figure. Many men are rather careless

about the tops of their boots, and bootmakers are apt to fall into the same moods as their customers. No well-dressed man wears boots slack at the ankle, and our object is to make our customers capable of being well-dressed. The trousers, like the grave, hide much bad work. but it is wrong to count on hiding anything.

Long Boots. Ladies are more particular about footwear than gentlemen, and the fair sex gives the shoemaker many a hard problem to solve Every now and then the fashion brings in a form of long boot, reaching almost to the knee, or shorter perhaps, but still a long-legged boot. The shoemaker must take the height desired from the lips of the fair customer, and measure accordingly. In addition, the height from the heel to the top of the boot should be taken.

Notes. For his own guidance, and without showing it to the customer, the shoemaker should make a note of peculiarities in the feet. Very beautifully formed feet are round at the instep, and measure more than feet of a lower-class model, and apparently broader. In some feet the toes spread out, while in others they are close and compact, seeming almost cramped, but not really so. We do not refer to defective feet at the moment, but simply to the actual differences among average healthy feet. Large joints of toes and ankles are very often a cause of trouble, and lownesss of arch or instep produces frequent disputes with customers, the high instep being a coveted mark of breeding, according to a popular fallacy.

A Shoemaker's Duty. Defective feet, the number of which only the shoemaker knows, bring special problems of their own. Deformities are out of the question. What we mean are slight defects produced by long standing, over-exertion, tight, ill-fitting boots, and such like. A shoemaker is not a doctor, but he takes on himself, if he is wise, some care and thought for the comfort and health of his patrons. Towards those little failings in the pedal equipment of his customers the bootmaker has a duty, which may be summed up in the words, "hide, help, heal." Unfashionable shapes of boot, square toes, low heels, and other remedies are not recommended by wise bootmakers; if a man knows his business thoroughly he can hide, help, and heal those minor ills of the feet, and no one, not even the customer, be one bit the wiser.

Working at Boot Tops. For a good while the making of tops has been a special branch of the boot trade; but that, for the present, may be left out of view. The duty of the bootmaker is to learn how to make a boot.

Variations in Value of Boots. We have first to select our leather, and cut it. To the average outsider, the wide range of prices charged for boots must be somewhat puzzling, and it is here the mystery begins. In bootmaking by hand we have not the same wide range of quality as in the factory, because no one thinks of asking for a hand-made boot unless prepared to pay a fair price. You can buy boots in the retail shops at 7s. 6d. a pair, and that money would not pay for hand labour alone. Cheap boots are machine-made; but there is more in it than that. Some machine-made boots are priced as high as 25s., and may be seen in the same shop as the cheapest class. The reason for this may well be sought. The secret is partly in the leather, but not wholly. The difference in the cost of material used for the highest and lowest class of boot is not over 5s. or 6s., taken in the mass. That is to say, take pound for pound of leather, web for web of lining, mounting for mounting, and the difference is not so very great. But you will get more pairs of low-class boots out of a hide than you can get of a better class. The cutting-out proceeds on quite different principles. A first-class boot top has no side seams; it is one solid front. This means a large amount of waste in a hide. Even the most skilful cutter has to lay aside for inferior purposes, or fling into the waste bag, a large portion of costly hide. A seamless boot is an altogether finer foot-covering than one with three seams, but it has to be paid for.

Economic Facts. Another thing that has sometimes been questioned may be explained here. How is it that you can occasionally get boots with uppers of fine leather at factory prices? The answer is, that these boots are made from the scraps left over from high-class boots. The fronts of all boots are fairly large pieces of leather; but take the half of a back, and you will see how you could get any number of them out of pieces of leather otherwise useless. Bootmakers are not exempt from economic law any more than any other class of workers, and the public may depend upon it that where a higher price is openly charged a higher value is given.

Cutting. We have taken in hand a pair of good average strong boots, of medium class. The uppers are to be of one class of leather, with side seams, and therefore in three parts, quarters, golosh, and vamps or fronts, properly so-called. The fine grain leather is laid on the cutting-table, with the measures. Near the table are hung files of shapes cut out of strong paper. These are the model patterns for every conceivable size. You can get them to buy; but in the old days, every bootmaker built up his own stock of patterns, and the practice made good workmen. The patterns for the size measured are selected, and the figures of the measure compared with those on the patterns. The foot of the customer may be built on finer lines than the pattern, or it may be shorter and broader. In the former case the cutting has to be fined so as to make a higher top with less breadth; in the latter case, the ends of the fronts and backs are to be shortened, and the fore parts of the fronts broadened.

Practical Method. Having settled the leading points of size and shape, we now take the cutting knife in hand [30]. Lay the pattern of the fronts on the leather laid flat on the board, and draw the point of the knife round the edges, making a clear sketch for the path of the cut.

Then drive the knife steadily along the lines, and roll and twine the threads over your knee, and make a uniform cord.

Waxing the Thread. Left dry and free the threads would quickly separate, and wear out singly; unprotected from water and weather, they would rot. Wax is the binder and preservative. Holding the piece of wax in one hand, the sewer draws the thread through the wax, and soon clothes the length in a fine, brown, shiny coat.

Bristles. The hardened threads taper to a point, but we could hardly make speed in sewing with only those points for needles. From time immemorial the trade has used bristles for this purpose, and modern ingenuity has not been able to improve upon the device. The bristles are from 4 in. to 5 in. long, and very strong. They have been specially selected by the bristle merchants who import the bear bristles for the brushmakers. Every bristle has what is technically called a *flag*; but to the common eye it looks like a split. Our neighbours, the brushmakers, like the flag to be as small as possible, and might be pleased to be without it if Nature would oblige; but to us a moderately-sized flag or split is useful. The thin section of the bristle can be made into a tie to twist on to the end of the thread, and the bristle secured without a knot.

Sewing. Tailors join the pieces of cloth about to be sewn with long stitches of white thread; but that is hardly practicable with leather. We fasten the pieces of the top together in a temporary way, by means of tacks. Let it be tacked together to see how it looks, and how the pieces form with each other. Having worked the top into shape, we can mark the lines where the sewing is to be, and pull out all the tacks excepting at the joints where the sewing has to be begun. Fix the parts in the boot clamp; bring it between the knees; pierce the two plies of leather with the fine awl; insert the bristle of the waxed thread, and draw it half way through. Sew the seam right up to the end, making small, even, regular stitches, pulling the thread tight at every stitch.

Machine Sewing. After the sewing machine came into use, topmakers had frequent disputes with the bootmakers as to what seams might be stitched with the machine and what should be sewn by hand. The practical and honest solution of that question is very simple. At least it was simple in the early days, because the machine could not sew as strongly as

Place the two fronts separate, so that you can keep the whole material of right and left boots together and without risk of mixing. The quarter, golosh, and vamps are cut, and then the linings and bindings are got. When you have piled together the makings of a pair of boots, the heap is of a size much larger than might be expected. A wise plan is to tie all the pieces of each top together and take out as required. Even though you are going to start to make the left upper next minute, it is right to place all the parts together, and see that they correspond. Many a member of the craft has had many bitter hours because he neglected that simple precaution, and landed in confusion.

Skiving, Sewing, and Stitching. The parts of the top have to be joined together, and it is desirable that the joints should be neat and smooth. A double thickness of leather at every joint would produce an ugly and uncomfortable boot. Obviously, the proper course is to thin the edges of the leather at the joints, and this is done by a process named skiving [31]. The skiving knife is a crescent of thin steel, with a sharp edge; but we have seen a good old workman doing it neatly on his lapboard with an ordinary cutting-knife. What is needed in the operation is steadiness of hand and a good eye, for the thinning must be graduated regularly all round and leave a clean edge on the front. Model skiving is about ⅜ in. broad, and true all round. Careful practice alone makes good skiving.

31. SKIVING, OR REDUCING THE EDGES OF THE UPPER PARTS

Stiffening. Before sewing the parts of the top together, we have to stiffen the backs; we have provided a good piece of leather for it, though some use linen. Carefully skiving the upper edges, we paste it firmly to the inside of the back, and leave to dry, preparatory to sewing.

Thread. Now we have to prepare our thread. Shoemakers are the last of the users of threads to retain the making of them in their own hands; tailors have surrendered their threads to the great manufacturers. Our thread is peculiar and special. It is composed of several strands of fine flax twisted and waxed into one. Take hold of the loose end of the ball of flax as it lies in its box, and draw out the length you can handle; double it back and draw out another skein of equal length, repeating till you have a thread of the thickness required—four-ply, five-ply, or six-ply. Cut off from the ball,

surely as the hand; but improved machines have done away with the difference to almost a complete extent. It is a safe rule, however, to sew with the hand those seams on which the stress of wearing is put. Reliability is one of the chief qualities of the hand-sewn boot. In the class of boot we are making, the stitching of the machine must be confined to ornamental uses, and for tacking in the lining.

Ironing. When the whole top has been sewn, the seams require to be ironed down. Smoothing irons are little bars of steel, of various breadths, from ½ in. to 2 in., and these are heated cleanly at the gas, or in the gas stove, and applied to the seams one by one. Heavy pressure is needed, and you bear your weight on the top of the iron handle, and rub firmly to and fro till the seam is flat to the leather. With heavy seams the smoothing iron may be helped with a gentle tapping of the hammer.

Linings. Faulty lining is a frequent cause of trouble to both bootmaker and bootwearer. It may be too tight and draw the top out of shape, or it may be too slack and form wrinkles inside the boot. Besides selecting the best and most suitable materials and cutting accurately, we must pay close attention to the sewing and tacking of the linings. Chamois leather is the highest class of lining, but it is too warm for many people; fine split leathers are ready to cut and break; and the most sensible material for ordinary wearing boots is a strong twilled cotton, with leather bindings. It is a waste of time sewing linings by hand. The best plan is to paste them carefully together and pass them through the sewing machine.

Tongue. This piece of soft leather, shaped like the section of a truncated cone, is tacked on to the mouth of the boot by the sewing that holds upper and front together, with an additional tack to the inside of the upper, making it like a two-hinged door.

Mountings. Fancy boots have mountings of various kinds, such as toecaps of enamel leather, and other trimmings; but plain boots have only the eyelets and hooks or fasteners. Punch the holes in a regular row up the two fronts, half an inch from each edge, fully half an inch apart, with the hand punch. Put the eyelets in the holes and clench them on the inside. The operation is simple; but it may be done carelessly. The eyelets of hand-made boots are generally neater than those done by the machine, the eyelets in the latter being, as a rule, broken out at the inside by the force of the clenching.

In this state the top goes into the hands of the shoemaker, as we curiously term the man who puts in the soles. We leave the final finishing touches till the hard work of the welting, soling, and heeling is all done. But it would hardly be fair to pass on without mentioning some others of the boots we have to make.

Button Boots. Most of the button boots on the market are made in the factory. Essentially of light style and material, this class of boot lends itself specially to the sewing machine. All the same, a capable workman can make a better and more lasting button boot than any combination of machinery. The fronts and backs may be the same as above described, but the uppers are quite different. Though, to outward appearance, the addition of the buttoning flap and the buttonholes seem the sole novelty, the fact is not so. The uppers are made full, so that the side under the flap comes close up to the other side.

Flap. This gives unity to the front, and at the same time protects the foot from the sewn seam of the flap. No matter how fine a seam may be, the double thickness of the leather is felt, and to a sensitive foot the irritation of the hard ridge would be intolerable. When sewing on the flap, this should be kept studiously in mind. The head of the flap continues the line of the upper round the leg, and curves round above the ankle-bone.

Elastic Sides. At present this form of boot is greatly out of favour, but there is yet a good trade done in them about the North of England, and among well-to-do elderly people who stick to the fashions of their early days. While elastic sides were fashionable, the artistic faculty of the bootmaker was not allowed to sleep. Uppers and fronts were decorated in various styles and some of the designs were really pretty. A common style was the long upper, reaching down to the toe-joints, coming from above the ankle and covering the whole instep, joining a golosh or bottom formed of one solid piece and sewn up the back. The upper of fine kid, and the golosh of enamelled leather, made an attractive boot.

Parts of the Upper. Spread out on the cutting-table, the upper-front had the appearance of a flounder without the fins. In cutting the bottoms, regard has to be paid to the rise of the foot above the toes. The front is cut to come almost within touch of the ankle-bone, the whole breadth of the ankle being left open for the elastic insertion or gusset. Of course, the backs are insignificant, and mere bits of triangular leather, but it must be remembered that these small pieces support the gussets and largely determine the balance of the whole boot. Backs of elastic sides have to be well cut, firmly and evenly sewn on the bottom, and stiffened with care. Gussets are woven silk or fine cotton, the indiarubber enclosed in the fabric, slender elastic strings giving a good spring. Round the gusset space, the lining is left open, and the gusset, cut to size, is sewn in, either by machines or by hand.

A style of elastic-side favoured by many has the appearance of a top boot. The whole front of the top is one solid piece. The back, also one piece, is joined in a side-seam. The gusset is oblong, narrow and circular at the bottom.

Continued

HOW TO VENTILATE OUR ROOMS

Entrance and Exit of Fresh Air. Exclusion of Dust and Draught. Methods of Securing Effectual Ventilation in Dwellings. Artificial Aids

Continued from page 3802

By Dr. A. T. SCHOFIELD

In an ordinary room there are three openings for air, besides what can enter through the walls; and these are the window, the chimney, and the door.

The Chimney. There is no doubt that the great safety valve of most rooms is the open chimney, which is of far more importance as an air-shaft than as an outlet for the smoke. Were it not for the English love for an open fireplace, and hence an open chimney, it is hard to say what would become of large numbers of the population. No chimney ought, therefore, to be stopped up; and, under ordinary circumstances, no room should be without one.

Ventilation really consists of a double process—the removal of foul air and the admission of fresh. Now, the chimney is principally of use for the former part of the work. Carbonic acid gas is very heavy, and with care can actually be poured from one glass into another. When it is expired, it is, of course, heated, and, being lighter than air, ascends to the ceiling. This is the time for getting it out of the room, and the best way is by an opening near the ceiling right into the chimney, with some simple valve (Arnott's) to prevent the smoke from coming out into the room. Without such a contrivance the carbonic acid gas cools and falls to the floor. This makes it very dangerous to sleep on the floor in close rooms without open chimneys. When CO_2 has thus fallen, the draught to the fireplace and up the chimney quickly carries it off.

The Window. The window is the second great means of ventilation. It ought, in the majority of rooms, to be so arranged as to be always open, by night as well as by day. It is impossible to overrate the beneficial advantages arising from this simple procedure.

No doubt considerable surprise is felt by some that no mention has been made of the escape of foul air by the window, and especially at the top. The window may be opened at the top as much as you like, but it cannot be too clearly understood that when so opened, as long as the air inside is warmer than that out of doors, the fresh air enters there, and the foul air does not go out. The window in this country is practically always an inlet—whether open top or bottom does not matter—and not an outlet. The chimney is *the* outlet. There should be, however, as we have shown, an inlet of 24 sq. in. for each person, and this can be made in various ways. One is by a simple window board about three inches deep, on which the lower sash shuts, so that while the bottom of the window is still closed there is an opening between the two sashes, admitting fresh air in an upward direction; or a board can be fixed across the front of the lower window-sill about six inches high, so that the lower sash can be raised behind it, and a double upward draught formed, the one between the two sashes, the other between the lower sash and this board in front.

Windows should always be open an inch or two at the top, and if at all large, a small pulley and a double cord should be fixed so as to pull the upper sash up and down easily without having to push and pull from the outside. The draught can be directed upwards in various other ways. The air can enter upwards behind a false cornice, so that when the window is apparently securely shut an opening is left above. An ordinary venetian blind serves somewhat the same purpose if partly let down. An ornamental glass screen, fixed on the lower sill so as not to rise with the window, is more ornamental than a board, and prevents any direct draught.

With these simple contrivances no draught is possible; and the cold air, directed upwards, falls in a gentle shower all over the room.

Tobin's tubes, already alluded to, are flat tubes against the wall, opening into the outer air below and into the room at about the level of the mouth, in an upward direction.

The Door. The third and worst way of ventilating a room is through the door. It is a capital saying, and should be enforced, that doors are made to shut and windows to open, and not vice versâ. If a room is already sufficiently ventilated, there will be no draught rushing in at the keyhole, as can be seen by the flame of a candle held there. If there is insufficient fresh air in the room, it will do its best to get in by the door, carrying with it, of course, all the smells, poison and sewer gas that may exist in any part of the house.

Ventilation is really self-acting. The poisoned air does its best to escape out of the room and the fresh air to enter, and if we do not absolutely prevent this by ignorance, these beautiful laws will work harmoniously and without effort.

Sitting-rooms and bed-rooms must not, of course, be overcrowded. Each person must be allowed *at least* 50 sq. ft. of flooring in a room 10 ft. high, and gas should never be used unless the rooms be very spacious: lamps and candles consume far less oxygen, and of course electric light is better still, but one single gas jet requires as much fresh air as five persons.

A great objection to free ventilation in towns is made by careful housewives on the ground of dirt. The matter is important, for there is no doubt that town air is laden with dirt of all sorts, and requires as careful filtering as water. This can be done effectually by muslin or perforated zinc stretched across the open window.

We have now pointed out some of the benefits of proper ventilation, but we have yet to mention one of its greatest advantages.

Catching Cold. Let us remember that the most fatal disease in England is consumption; then come bronchitis and inflammation of the lungs; and mark that one of the commonest ways these begin is by our "catching cold" on going from close, unventilated rooms into the open air, and that the surest general preventative we can adopt against these diseases is to have our rooms (and especially our bed-rooms) fresh and well ventilated. Sitting in close rooms with sandbags on the tightly closed windows, list round the doors and the register down in the chimney to avoid cold, only ensures catching it; while letting the foul air freely out and the fresh freely in is the surest safeguard against it.

We must look a little further still into one or two points before the subject is dismissed. Theoretically, the cold air should enter at the floor level and the hot foul air leave at the top. In good houses the latter is frequently carried out not only by valves at the top of the chimney breast, but by holes in the central ornamentation, in the ceiling especially, when there is any gas burning, so that the fumes and bad air can be carried off directly. But the admission of fresh air at the level of the floor is a different matter, and is found in practice to cause such cold feet that it is seldom admitted lower than three or four feet from the ground. In cold weather natural ventilation is even more difficult on account of the draught.

Of course, if the air be warmed all the difficulty is solved. The opening can be larger, the current slower, and the air changed more frequently; but, as yet, warmed fresh air, which is the key to successful ventilation in this country, is almost unknown.

How Wind Aids Ventilation. The wind is a great ventilator both by perflation, or wind blowing in, and by aspiration, or wind sucking out. In the Sylvester system there are two cowls, the one facing the wind and blowing fresh air into the chamber, and the other with its back to the wind and drawing the foul air out.

Over a chimney the wind generally aspirates, or draws the foul air out; at a window it generally perflates, or blows fresh air in. Wind can change the air of a room 100 times an hour. You can tell if your room is ventilated from the house or open air by placing a candle flame at the keyhole. If the flame be blown into the room, your ventilation is wrong.

Of course, windows should be inlets and chimneys outlets; but their rôles are sometimes reversed. If there be no fire and the chimney be very cold, air may come down it into the warm room, or if the chimney top be lower than others surrounding it, the wind may strike them and be deflected down it.

A fire, however small, is a great ventilator. It draws 15,000 ft. an hour up the chimney. Of course, fires ventilate the room best below the level of the mantelpiece. The colder the room, and the hotter the external air, the more need is there for the open window.

In addition to the openings described, there are Ellison's bricks and Sheringham valves communicating directly through the wall with the open air. In both, the external opening should be smaller than the internal, thus modifying any draught. The Sheringham valve often acts as outlet as well as inlet: and so, of course, in certain conditions may the window itself, though normally it is an inlet at both top and bottom.

The entrance of air through the walls, too, must not be forgotten; all depends, of course, on the difference of temperature between the internal and external air. A closed room with 34 degrees difference between the air inside and outside will change its air twice as fast through the walls as in a room with the window open and seven degrees of difference of temperature within and without. With a difference of only four degrees between the internal and external air, it will pass through a sandstone wall at the rate of 4 cubic ft. per hour per square yard; through a brick wall, 7 cubic ft; and through a mud wall, at the rate of 14 cubic ft.

Forced Ventilation. In artificial or forced ventilation there is extraction or propulsion of air by heat, steam, fans, etc. In mines there is a large fire at the bottom of the upcast shaft, or an exhaust fan at the top. A large hall often ventilates a house in the same way. In crowded meetings and churches some such system is needed. The earliest illustration of artificial ventilation is in a bee-hive, where the air in the middle is kept remarkably pure. It is said that at the entrance some twenty bees keep up a steady hum with their wings, which they flap without stopping in successive relays, and this forces fresh air in.

Schools must have warmed air and artificial ventilation on account of the small cubic space allowed, and the air is often changed without draught ten times instead of three times an hour.

Of course, at present all ventilation is a voluntary matter, for air is the only food that man is allowed to adulterate to any extent at will. There is no doubt that all efficient ventilation for the public must be self-acting, give no trouble, and require no care in adjustment. On the whole, a window a little open at the top with, if possible, something to direct the air upwards, and an open fireplace, are the simplest and best methods at present; but it is quite possible that ere long, in flats, a central furnace in the basement, kept up at a small cost, will be arranged to supply through pipes fresh warmed air to each one, so that the rooms can be perfectly ventilated in the coldest weather. Ventilation in sick-rooms is touched on in Home Nursing in the section on Ill-Health.

Continued

THE NATURE OF ELECTRICITY

Matter, Energy, Ether, and Electricity. The Electrons. Electromagnetic Theory of Light

Continued from page 3898

By Professor SILVANUS P. THOMPSON

Matter and Energy. Often as it has been said that we are profoundly ignorant of the nature of electricity itself, there is yet a great deal that we know about it, and the attempt must now be made to explain briefly what is known.

Not many years ago it was supposed that the only kinds of things of themselves in the physical Universe were two—*matter* and *energy*. Matter, that which possesses the fundamental properties of mass (and therefore is heavy) and of inertia, and which, though its atoms are of some 80 different kinds, called "elements" by the chemist, is subject to a law of conservation—we can neither create it nor destroy it. The quantity of matter in the Universe appears to be a fixed amount. Energy, that which, acting on matter, manifests itself in the various physical forces; the kinetic energy of moving bodies, by virtue of which they can perform work; the potential energy of systems; bodies that have had their configuration altered by doing work upon them; the energy of heat, which is a mode of internal motion of the molecules in the mass, in whatever kind. Energy is likewise subject to a law of conservation—we can neither create nor destroy it; but we can transform it from one species to another, and we can dissipate it into forms that are no longer available for doing work.

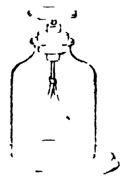
Early Theories regarding Electricity. At the time when the doctrines of energy were being developed, it was thought that electricity itself was merely another mode of motion or form of energy, just as heat is. Prior to that, electricity had been supposed to be a sort of imponderable fluid—a weightless gas; and magnetism had also been set down under similar categories. Both had been vaguely classed amongst the so-called "forces of Nature." But that term is unscientific, since the word force (unless qualified by some adjective, such as electromotive, to show that a non-mechanical effort is meant) in its precise signification is restricted to mean that which exerts either a mechanical push or a mechanical pull on matter. But electricity of itself is not a push or a pull on matter; it is therefore not a force, neither is magnetism. But just as matter can be acted upon by energy, and become the vehicle for the manifestations of energy, so electricity can also be acted upon and become the vehicle for the manifestations of energy. In this respect electricity itself resembles matter.

The Ether. There is, however, yet another thing-of-itself in the Universe, that mysterious medium which fills all space between the stars, and apparently permeates also through all solid bodies. It is called the luminiferous ether, because we cannot conceive of the waves of light coming to us from the sun or the stars unless they are waves of some medium that stretches throughout interstellar space. And because the speed of propagation of waves in any elastic medium depends only on the elasticity (stiffness) and density of that medium, and as the speed of light-waves is so enormous (186,000 miles per second), we know that the stiffness of the ether must be enormously great, for its density is marvellously small. It behaves in some respects like a jelly of extreme rigidity, yet of extreme tensity also, being less dense than the very lightest gases. It used to be debated whether the ether were not a kind of matter, a sort of gas, lighter than hydrogen. It also appears to be subject to a law of conservation—we can neither create it nor destroy it. Moreover, like matter, it can act as the vehicle of energy. For light-waves are a form of energy, and they are conveyed by the ether.

The Electromagnetic Nature of Light. Wheatstone, in 1834, measured the velocity with which an electric impulse is propagated along a wire, and found it to be almost the same as the speed of light. This, and certain other relations between the electric units of measurement, caused Clerk-Maxwell, in 1864, to propound the theory that the waves of light are electromagnetic waves. He studied the laws of wave-motion as applied to electricity, and showed that they would account for many observed facts; for example, that glass and other transparent solids are non-conductors of electricity, and that the metals that possess electric conductivity are opaque to light. This theory was generally accepted by British physicists, who tested its truth in several ways; but on the Continent it was not accepted until 1888, when Hertz had shown how to set up electromagnetic waves by the sudden oscillatory discharge of condensers, as explained on page 3898. An electromagnetic wave is one in which there are electric displacements, which are propagated in space from one point to another, accompanied by magnetic displacements at right-angles to them. The main difference between them and ordinary light-waves is in their size, for the waves of visible light are very minute, from 15 to 30 millionths of an inch in length, while the Hertz waves may be from about half an inch up to several hundred feet in length.

This identity of species between light-waves and Hertz waves leads to the question whether the ether is itself of an electrical nature, since what the older physicists regarded as waves of actual motion in the ether are explainable as electromagnetic waves.

Dual Aspect of Electricity. From a very early date it was recognised that when electrification was produced, by friction or otherwise, there were two kinds produced—a *vitreous* charge and a *resinous* charge. The former was obtained on the surface of glass by rubbing it with silk; the latter on resin or sealing-wax by rubbing it with flannel or fur. A charge of either of these kinds will attract bits of paper, or straw, or a feather, or other light thing. But each kind apparently repels itself. Thus, if a rubbed glass rod is hung up in a silk stirrup, and another rubbed glass rod is held near it, the suspended one is repelled. On the other hand, the two opposite kinds attract one another. Simple experiments about these relations are readily performed with the aid of a gold-leaf electroscope [250], which consists of two narrow strips of thinnest gold-leaf mounted on a brass stem, which is supported by being fixed in a glass tube which passes through a cork of paraffin wax in the top of a glass jar. It is usual to fix a brass plate on the top of the electroscope. Suppose the end of a warm glass tube to be rubbed on silk, and that the tube be then made to touch the plate. The two gold leaves immediately open out as though they repelled one another; and when the glass rod is removed they will still remain slightly divergent, because part of the charge from the glass remains in the instrument. When once so charged, the difference between the two kinds of charge is readily observed, as follows. If the rubbed glass rod be again brought near without touching, the gold leaves are seen to open out more widely; but if a rubbed stick of sealing-wax or other resinous body be brought near, the leaves are seen to close up toward one another. If the gold-leaf electroscope be dry and clean, so that the metal part is really well insulated, it will keep its charge for several hours, or even days.



250

Positive and Negative. To account for these facts several theories were advanced. It was thought that there were two kinds of electricity, the vitreous being called *positive electricity* and the resinous *negative electricity*. It was, however, observed that when two things were rubbed together, if one became positive, the other always became negative; also, that the amounts of the charges so produced were always equal to one another, so that if allowed to discharge into one another they re-combined and neutralised one another. This led to a tentative theory of the two fluids which could not be separated without doing some work to part them asunder. The two-fluid hypothesis in turn gave way to Franklin's one-fluid theory, according to which, though electricity itself was regarded as a single fluid, distributed everywhere, but neutral in its properties, whenever work was done by moving it, so as to produce a surplus at one place and leave a deficit at another, the surplus and deficit at once showed those properties of attraction that had first led to the discovery of the existence of electricity. The one doubt at the time was whether the vitreous or the resinous state was the surplus. Franklin concluded that the vitreous state was the surplus, and therefore called it *positive*. If the one-fluid theory be true at all, the resinous or negative state is, however, most probably the surplus. The main reason for this assertion is that a resinous charge is more readily dissipated than a vitreous of equal amount. According to the two-fluid theory, a current is a double flow of positive electricity one way, and of negative electricity the other way, along the wire. According to the Franklinian theory, the current flows only from positive to negative. The more probable theory is that if electricity is a fluid at all, the current consists of a flow of resinous electricity in the direction from negative to positive. It is certain that in electrolysis there are two sets of *ions*—that is, electrically-charged atoms—which are propelled by the action of the current in opposite directions, the anions (such as chlorine and oxygen) moving from negative to positive, or up-stream; the kathions (such as hydrogen and the metals) moving from positive to negative, or down-stream.

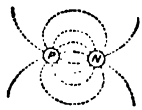
Atomic Nature of Electricity. There is as much reason to regard electricity as atomic as to regard matter as atomic—that is, Nature appears to have ordained that electricity, whatever it is, exists in certain definite very minute quantities of the same magnitude, each of which cannot be subdivided into any smaller quantities. This is, indeed, an inevitable inference from Faraday's discovery of the laws of electrolysis. Thus, when hydrochloric acid, the molecules of which consist of an atom of hydrogen combined with an atom of chlorine, is electrolysed, each molecule splits up into two *ions*—namely, a hydrogen ion, consisting of a hydrogen atom charged with a positive atomic charge of electricity, and a chlorine ion, consisting of a chlorine atom carrying a negative atomic charge of electricity. Now, the electrochemical equivalents of the elements are known. To dissociate one gramme of hydrogen from chlorine requires 96,600 coulombs of electricity to be passed through the electrolyte. The physicist has further concluded, from various other experiments, that 1 gramme of hydrogen contains no less than 10^{25} (that is 10 quadrillions) of atoms. It follows that each atom of hydrogen carries a positive charge of $9{\cdot}66 \times 10^{-21}$ of a coulomb; and each atom of chlorine an equal negative charge.

Electrons. This natural unit or atomic quantity of electricity has been called an *electron*. An ion is, therefore, an atom of matter combined or associated with an electron. Some atoms are, as the chemists say, divalent, and carry two electrons; thus, the oxygen atom carries two negative electrons, and the zinc atom carries two positive electrons. When one atom of oxygen carrying two negative electrons combines with two atoms of hydrogen, each carrying one positive electron, there is produced one molecule of water. The electrons then are known to us as associated with matter. It is

certain for quite other reasons that negative electrons can exist by themselves. It is not so certain that a positive electron can exist by itself. Indeed, one view is that there are no positive electrons; that a positive ion consists not of an atom of matter plus a positive electron, but of an atom of matter that has got one negative electron too few associated with it. According to this view, we can account for the production of electrification by friction as follows. When we rub two things together, if they are of different materials, one will part with its electrons more readily than the other, so that when we rub one surface over the other, and part them, one will lose some of its electrons and the other will gain them. Thus, if we rub celluloid with flannel, the flannel loses some of its (negative) electrons and becomes positive, while the celluloid gains the (negative) electrons and becomes negative. If two pieces of the same substance be rubbed together the gains and losses on each piece are, on the average, alike, and no electrification of either piece is observed. But this is no longer true if the two pieces are not in similar condition. Thus, rough glass becomes negative if rubbed on smooth glass; and non-conducting substances when hot generally become positive if rubbed on a cold piece of the same substance.

Electric Stresses. If we rub glass on silk there is no sign of electrification shown until we separate them one from the other, when we find the surface of the glass is positive and that of the silk negative. Now, since a positive and a negative charge attract one another, it is obvious that we cannot draw them asunder without expending some energy in the act. Where does this energy go to? It certainly remains in the "system"—meaning by that term the two charged bodies and the medium between them—for it can be given back as work done when the two charged bodies run together again. The case is analogous to that of two bullets tied together by a short spiral spring or a piece of elastic indiarubber. When we separate them they apparently attract one another back; but the energy given to them in pulling them apart resides not in the bullets, but in the strained medium that connects them. A closer analogy is afforded by the mutual attraction between two magnet poles of opposite kinds, one north, one south. Now, in that case, as explained on page 560, we can follow up these actions, and can show that the magnetic stresses follow certain curved lines through the medium. In a precisely similar way it is possible to explore experimentally the space between two electrified bodies.

Lines or Tubes of Electric Force. If we place a dry glass plate on a non-conducting table, and bring to touch it at two points two wires which are kept highly electrified by a suitable source, and then sprinkle between them certain powders, such as warm powdered tourmaline or crystallised quinine powder, we find that the powder arranges itself in more or less defined lines, just as iron filings do in a magnetic field. Fig. 251 gives diagrammatically the curves of the electric lines in an electric field of force between a positive body, P, and a negative body, N. The whole intervening part of the medium is, in fact, in a state of stress, as revealed by these curves. Along the lines there is a tension; transverse to them there is a pressure; with the result that these stresses in the medium tend to urge the two charges toward one another.



251

But, considered from the electron point of view, each "charge" consists of electrons, as many positive electrons on one as negative on the other, if the charges be equal. The stresses then in the medium may be mapped out as curving lines—or, rather, as tubes—each of which terminates at one end at a positive electron, at the other end on a negative electron. Two similarly electrified bodies repel one another; or, rather, the stresses tend to urge them apart. Fig. 252 shows the tubes of electric force in the neighbourhood of two positively-charged bodies. In this case the tubes have each one end on one of the positive charges, and their other end on the negative charge on the walls or other surrounding or neighbouring conductor. Every atom, at any rate under ordinary conditions, has an electron associated with it, and therefore has an electric "tube" proceeding from it.

252

Electrons and Conduction. While in a non-conductor or dielectric medium, such as air or glass, we can have a permanent state of electric stress between two charges, this is not so in conductors; for if we impart to any part of a conductor a charge, that charge instantly spreads through the metal. When the whole conductor has come to the same potential the flow ceases. Apparently, then, electrons can move freely through the metals. According to this view, when we join a battery to a loop of wire positive electrons rush in at one end and negative at the other, and the tubes which extend across the space from a positive to a corresponding negative electron must rush along with the electrons, and finally collapse into the wire as the electrons meet. In the case of a telegraph wire stretched over the earth and connected down to earth at the distant point, the current, on this view, will consist of the two electrifications travelling along in company from the battery and toward the distant end, one travelling along the wire, the other travelling on the earth, with "tubes" stretching between them and also travelling along. The tubes which thus connect the positive and negative electrons sweep through the dielectric; and the energy path thus lies, not in the conductor, but in the intervening or surrounding medium.

NOTE. In the diagram on page 3088, instead of *charge* read *discharge*, and instead of *discharge* read *charge*.

Continued

Group 11 CIVIL ENGINEERING 28 Continued from page 3817	# WATER SUPPLY **Rainfall and its Measurements. Sources of Public Water Supply. Types of Wells Storage and Impounding Reservoirs**

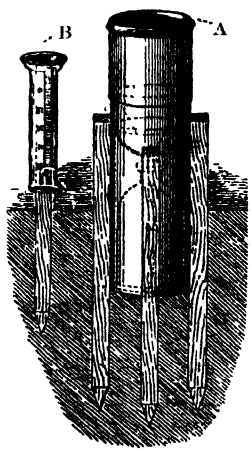
By Professor HENRY ROBINSON

PRELIMINARY to a study of the great subject of Water Supply we must make ourselves familiar with the approved methods of estimating rainfall. Evaporation from the sea and the surfaces of land causes air to become laden with water vapour. On cooling, the water vapour condenses and forms mists and clouds. Excessive condensation leads to rain. Variations of temperature and barometric pressure alter the capacity of the air for retaining water vapour and mists. Rainfall is measured and recorded in terms of the depth of water that would be caused if it were collected on a flat area, and assuming that no water could run on to it from an adjacent area, and no evaporation take place.

The late Mr. G. J. Symons may aptly be described as the pioneer of meteorology as far as rainfall is concerned. He was the originator of the British Rainfall Organisation, now carried on by Dr. Hugh Robert Mill, at the Camden Town Station in London. The records are published in a book called "British Rainfall," and deal with about 4,000 returns.

The mean annual rainfall in England varies from about 20 inches to about 160 inches—the latter in the Lake District. This, however, is far exceeded in places abroad, as, for instance, in Chena Pungi, in Assam, where, in 1861, the rainfall was 805 inches, of which 366 inches fell in July. The mean annual rainfall there is 559 inches.

Rain-gauges. The amount of rainfall is ascertained by rain-gauges, the most common being the Snowdon [1]. This consists of a brass cylinder, A, which is sunk into the ground, leaving the lip about one foot above the surface. Inside this is a funnel, which collects the rain and leads it into a bottle resting on the bottom of the cylinder, the amount being measured daily by means of the graduated glass, B. The bottle holds about three inches of rain. If the rainfall exceeds this the excess is collected in the inner can.



1. SNOWDON RAIN GAUGE

Various forms of self-recording rain-gauges have been invented, one of which is Negretti & Zambra's [2]. The rain enters a collecting funnel, A, and runs into a tilting-bucket, B, divided into two equal parts, tipping over when ·01 inch of rain has fallen. This advances an escapement wheel one tooth, and by means of a perfect helix attached to this wheel, the long lever carrying a pen, as shown, is raised until an inch of rain has fallen. When this point is reached, the lever falls to the other end of the helix, and the recording pen runs back to zero, and begins to record a second inch. The recording drum is worked by clockwork, the chart being divided into ·05 inch, and lasting a week. The escapement wheel is also divided into ·01 inch of rainfall.

A later pattern of the machine is the Electrical Self-Recording Rain-gauge, which is very similar to the above, and another gauge is Richard's Self-Recording Rain-gauge [3]. In the latter a funnel leads the rain into a tilting bucket divided into two equal parts. One of these compartments being under the funnel, when rain falls the balance descends, a writing pen recording this motion on the revolving drum. The tipping of the first compartment causes the second to place itself under the funnel. The filling and emptying of each compartment are alternately and automatically produced, and to each of these double operations corresponds a rise and a fall of the writing pen.

In Halliwell's Standard Self-Recording Rain-gauge, the rain from a receiver passes through a wide pipe to a cylinder, in which is a float, bearing a vertical rod, that raises or lowers a sliding pen arrangement. As the water accumulates, the float and pen rise, the latter recording continuously the rate of rainfall. Shortly before the pen arrives at the top of the chart, the cylinder is emptied by a syphon arrangement, the pen returning to zero and starting registering again.

The diameter of a rain-gauge should never be less than five inches. The late Mr. Symons experimented with gauges from one inch diameter up to six feet square, and found them all agree within 5 per cent., and (excluding the very large ones, which cause an excessive deposit of dew) the differences are generally within 2 per cent. Rain-gauges placed high above the ground collect less rain owing to the high velocity of the wind causing an eddy over the opening, an instance of this being a gauge which collected 12 inches on one of the towers of Westminster Abbey, 18 inches on a roof close by, and 23 inches on the ground.

Rules for Rain-gauging. It will be helpful to give the following abbreviated list of the rules issued by Dr. Hugh Robert Mill for the use of the observers all over the country who are taking records for him.

Selection of Site.—A rain-gauge should be placed on a level piece of ground, and clear of all objects higher than itself. If an open site cannot be obtained, the exposure to the south-west and north-east should always be free. The height above sea-level should be determined.

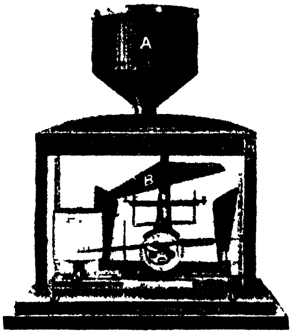
Mountain and Moorland Sites.—Gauges should not be unduly exposed to the sweep of the wind. A turf wall about two feet high, surrounding the gauge at from 6 to 10 feet distant, is recommended.

Placing the Gauge.—The gauge should be firmly fixed so as to prevent tilting, and should be surrounded with short grass.

Height above Ground.—The funnel should be set exactly level and one foot above ground, but never more than 1 ft. 6 in.

Small Amounts.—If the gauge contains less than ·01 of an inch, but more than half that amount, it is entered as ·01. If less, it is not counted.

Snow.—To measure snow in a Snowdon gauge all that is necessary is to melt the snow in the funnel in front of a fire and measure the resulting water. To estimate by depth, take the average depth over a considerable area, when one-twelfth is the equivalent amount of rain.



2. NEGRETTI & ZAMBRA'S RAIN GAUGE

Mean Rainfall. In dealing with rainfall records, the late Mr. Symons established the method of reduction to a percentage of the mean fall as follows. Suppose a place has a mean annual fall of 30 inches, which is increased for one year to 40 inches, $40 \div 30 = 1 \cdot 3\dot{3}$, or the fall for that year was $33\frac{1}{3}$ per cent. more than the mean. It may be well to explain that by *mean* or *mean fall* is meant the arithmetical average fall of any whole period or record.

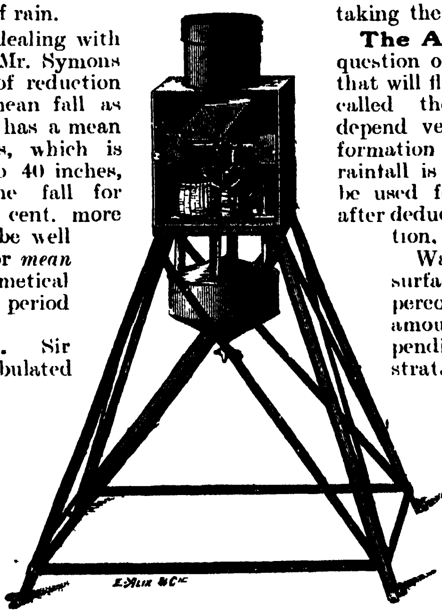
Rainfall Data. Sir Alexander Binnie has tabulated statistics [see table on next page] to show the probable maximum error in an estimate of mean annual rainfall (taken from a large number of records all over the world) for periods of from one to thirty-five years.

The Mean Annual Rainfall. Thus, if records are available over a period of ten years, the error in estimating the mean annual rainfall is not likely to exceed 8·22 per cent.

Engineers generally agree that the three driest years would yield one-sixth less than the mean. The late Mr. Symons, after careful investigation, made it one-fifth or 80 per cent. of the mean. For the British Isles Dr. Mill anticipated that the wettest year would exceed the average by 43 per cent., and that the driest would fall below it by 29 per cent. Sir Alexander Binnie made these figures 45 per cent. and 24 per cent. respectively.

Gauging for Waterworks. When, however, an engineer has to deal with watersheds for waterworks purposes, where the area is limited, more accurate information than the above is required, and the question of the flow off the area for very much shorter periods must be taken into consideration on account of the fact that the rainfall relied on for filling storage reservoirs falls chiefly in the winter months. This being the case, it is obvious that the season of the year plays a very important part, and, together with the falls over short periods, requires careful study. Also a greater number of gauges are necessary in order to get accuracy, as it has been found that in small areas gauges placed in different positions in a valley gave quite different results.

The rate at which rain falls and flows off the ground is a point which should always be kept in mind when taking rainfall figures into consideration, as this affects the question of waste weirs for reservoirs, and does not appear when taking the average of a whole year.



3. RICHARD'S RAIN GAUGE

The Available Rainfall. The question of the amount of the rainfall that will flow off a catchment area—called the *available rainfall* — will depend very largely on the geological formation of that area. The available rainfall is that quantity which could be used for water supply purposes after deducting the loss due to evaporation, absorption, and percolation.

Water, after falling on the surface of the ground, tends to percolate into the soil, the amount of this percolation depending on the character of the strata, or its capacity to absorb moisture, and on the natural slope of the ground. The greater the slope the larger the quantity that will run off to feed the watercourses to which all surface water ultimately arrives. The rain passes through the soil for a certain depth until it comes to the natural surface of saturation; from thence it will follow the line of underground flow, this line depending on the resistance of the strata. The percolation may be permanent, in which case it is entirely lost as far as that particular watershed area is concerned, or it may be temporary, when it will sink below, and, after travelling underground, will issue in the form of springs at a lower level, and join

Period of records—in years.	Percentage of deviation of the mean annual rainfall of the period from the true mean annual rainfall.	
	Above	Below
	Per cent.	Per cent.
1	51	40
2	35	31
3	27	25
5	14·93	14·93
10	8·22	8·22
15	4·75	4·75
20	3·24	3·24
25	2·75	2·75
30	2·26	2·26
35	1·78	1·78

the same stream that is fed from the surface water. An illustration of this occurred in a case in which the writer was engaged, where a fault in the strata compelled the water to issue in the form of a spring about half a mile below where it had been intended to place a dam for impounding purposes, whereby only about half the estimated available rainfall would have been available.

The most accurate way to arrive at the available quantity is to gauge the stream, and then, by directly comparing the quantity flowing with the quantity that has fallen and been collected in rain gauges, the amount of the loss by the before-mentioned causes can be estimated. Some close approximation can be made to the amount by a comparatively short period of gauging, if a long record of rainfall gaugings be available; but it must always be borne in mind that the heavy falls over short periods are more important than averages for this purpose, and also that the condition of the ground when the rainfall takes place, whether after a drought or not, materially affects the percolation.

Percolation. The question of percolation has received considerable attention at different times, and experiments have been made with what are called *percolation gauges* to see the results with various soils. Percolation at one period may have an influence on springs for months.

A wet winter will give abundant springs in the following autumn, but if that be followed by a dry winter the latter will obliterate the effect of the previous wet winter.

In summer there is no percolation as a rule. The records from percolating gauges are usually divided up in half-yearly periods of summer and winter. The figures given in the table in next column for percolating gauges were given in "British Rainfall."

An examination of these figures shows that the percolation varies considerably with the two sets of gauges, indicating that percolation gauges do not give so reliable results as river gaugings, which afford the data required by engineers, and are far more useful, although more difficult to observe.

Absorption. If the watershed be hilly and the surface only slightly absorbent, there is the minimum absorption, and, the area having a sloping surface, the rainfall passes to the streams with the least evaporation. If the area be flat, with a pervious soil, the bulk of the rainfall passes underground. If the soil be clayey instead of absorbent, the maximum loss by evaporation takes place. If the surface of the gathering ground be wooded, it affects the amount lost by evaporation, and the rate at which the rainfall passes off to the streams, as large quantities are retained by the trees which shelter the surface from the sun's rays. If such an area were cleared of timber, the rainfall would pass more rapidly to the streams. In Humboldt's "Cosmos" the author describes an interesting case bearing on this, of the effect of clearing forests in one of the countries that he visited.

Evaporation. The evaporation in this country is generally taken at between 12 and 16 inches. At Nagpur, in India, the evaporation was found to be 4 feet in 272 days of dry weather, while from the large reservoirs supplying Manchester it has been found to reach one-tenth of an inch per day in times of drought. The following are some figures on evaporation from open reservoirs in America:

At Ogdensburg (New York)	49·4″ per annum
„ Syracuse (U.S.A.)	50·2″ „
„ Salem „	56·0″ „
„ Cambridge „	56·0″ „

Dew Ponds. Under certain conditions evaporation ceases, and water is condensed on the surface of reservoirs. On Salisbury Plain, and other elevated districts on the chalk formation, small ponds called "dew ponds" are constructed on the tops of the hills where little or no surface water can run into them, yet a small supply of water is obtained, owing to the very heavy dew arising from the condensation of the vapour which is evaporated from the surface of the chalk.

AT APSLEY MILLS, HEMEL HEMPSTEAD.

	Summer.	Winter.	Year.
Rain	12·55″	13·51″	26·06″
Percolation (3 ft. sand)	3·91	12·55	16·46
Evaporation	8·64	0·96	9·60
3′-3″ of chalk Percolation	1·83	10·42	12·25
Evaporation	10·72	3·09	13·81
3′-3″ of earth Percolation	1·54	11·21	12·75
Evaporation	11·01	2·30	13·31

The Nash Mills gauges gave as follows:

3 ft. of chalk Percolation	10·65
Evaporation	17·19
Rainfall	27·84
3 ft. of earth Percolation	6·52
Evaporation	21·32
Rainfall	27·84

In all schemes for the utilisation of the rainfall it is necessary to take into consideration

the periods of drought; and in estimating the yield from a gathering ground the quantity to be relied on is based on the available rainfall over the three consecutive driest years. The term *drought* can be regarded only as a relative term. The late Mr. Symons has suggested these definitions:

ABSOLUTE DROUGHTS.—Periods of 14 or more consecutive days absolutely without rain.

PARTIAL DROUGHTS.—Periods of 28 or more consecutive days in which the total rainfall does not exceed 0·25 in.

LONG DROUGHTS.—Periods of not less than 60 days with a total rainfall of less than 2 in.

Storage. The yield from gathering grounds in times of drought is of extreme importance, as the question of providing storage directly depends on it.

Some engineers provide storage for 200 to 250 days' supply, and rely on one-third or one-fourth of a cubic foot per second during the drought from each 1,000 acres of gathering ground.

The following formula for finding the number of days' drought to be provided for was employed by the late Mr. T. Hawksley:

$$\text{Number of days drought} = \sqrt[3]{\frac{500}{\text{available rainfall of 3 dry years.}}}$$

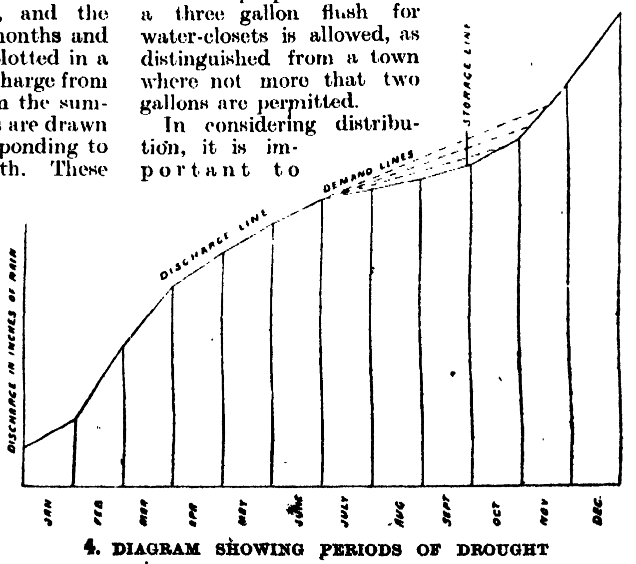
The relation between the size of the gathering ground and the amount of storage required is one of the first considerations. If the demand is small compared with the average yield of the gathering ground, the amount of storage may be small, or nothing at all. The exact amount of storage that is required to maintain a certain supply from any river can be best determined graphically, if gaugings are available throughout the period of greatest drought. Fig. 4 shows how this can be done.

The vertical scale represents the discharge of the river expressed (preferably) in inches of rain over the whole gathering ground, and the horizontal scale represents time in months and years. The results of gaugings are plotted in a cumulative line, showing the total discharge from the beginning up to any date. From the summits of the *discharge line* straight lines are drawn (dotted in diagram) at a slope corresponding to the demand in inches of rain per month. These *demand lines* will bridge over the depressions (representing droughts) and cut the discharge line again if it rises rapidly enough after a drought. The greatest vertical distance between the discharge line and the demand line gives the exact measure of the storage capacity that is required to meet the demand throughout the drought in question. If the demand line is on the same, or on a flatter slope than the flattest part of the discharge line, no storage is necessary. If a second diagram is plotted with a vertical scale representing inches of storage required, and a horizontal scale representing inches of demand per annum, a curved line can be drawn, giving the storage required for any rate of demand.

Water Supply in Towns. The amount of water required for the supply of a town depends on several considerations, one important factor being the extent to which it is wanted for manufacturing or trade purposes. For ordinary domestic use about 10 gallons per head per day will suffice provided there be no avoidable waste. Provision has to be made for gardens, stables, manufactories, public baths and washhouses, street watering, sewer flushing, fire extinction, etc. For these requirements another 10 gallons per head per day has to be provided. Where the town does not require water for trade purposes, 25 gallons per head per day should be a safe calculation. The following data may be given to illustrate this. Bristol has a consumption of about 22 gallons per head per day, which is ample, whereas Glasgow has about 50 gallons per head per day, of which 19 gallons are for trade purposes, the remaining 31 gallons being for domestic supply and for public purposes. The Glasgow water being soft (having only one degree of hardness), the minimum of soap and the maximum of water are used, while the charge for water for non-domestic purposes is only 4d. per 1,000 gallons.

At Bristol, on the other hand, the water has 22 degrees of hardness, which means much soap and little water for washing purposes, and the cost for non-domestic water is from 6d. to 1s. 6d. per 1,000 gallons. Residential cities like London, Edinburgh, and Dublin take about 33 gallons per head in the first-named to 38 gallons in the other two. Of the manufacturing towns, Liverpool takes about 30 gallons, Manchester 28 gallons, Belfast 35 gallons, Dundee 48 gallons, and Aberdeen 43 gallons. The consumption for domestic purposes is increased in a town where a three gallon flush for water-closets is allowed, as distinguished from a town where not more that two gallons are permitted.

In considering distribution, it is important to



4. DIAGRAM SHOWING PERIODS OF DROUGHT

remember that the consumption of water is not uniform throughout the day, as great fluctuations occur at different hours of the day and at different times of the year.

Sources of Water Supply. An urban or rural district having to be supplied with water, the first thing to consider is the possible sources, having regard to the quantity required and the cost of the works involved. These can be defined as consisting of either gravitation or pumping works, the former enabling the water to be collected from surface sources (such as streams receiving the rainfall flowing off what are known as *gathering grounds, catchment areas*, or *watersheds*), the last mentioned including water raised by pumps from a stream to a reservoir at a higher level, or water raised from an underground source to a similar storage reservoir, or to a water tower enabling the necessary head or pressure to be obtained in the distributing pipes throughout the area of supply to reach the highest buildings.

Underground Sources. If the water from an underground source has to be utilised by sinking a well, it must be remembered that the lowest water-level in a deep well in this country usually occurs in the autumn, and the most rapid rise occurs in February. In selecting the spot for sinking a well, it is necessary to examine carefully the surrounding district, and to form a clear idea of the physical and geological conditions, so that the well may be sunk at a point where the dip of the strata which are water-bearing will bring the water towards the well. The depth to which a well has to be sunk to ensure the requisite supply involves a study of the area of the underground water that can be drawn to the pumps at the bottom of the level. At the bottom of a well a chamber can be made or adits driven to store water. This enables the pumps to be at work only during ordinary hours, as they are made powerful enough to deal both with the regular flow to the well and with the increased volume due to storage.

Inverted Cone. The effect of pumping is to produce what is known as a curved *cone of depression*, or *inverted cone*, due to the resistance of the water passing through the strata from the higher water-level around to the lower level of the pumps. To assist the passage of the surrounding water to the pumps, adits are often driven from the bottom of the well. These intercept fissures in the strata, thus tapping large volumes of water.

The effect of withdrawing water from its underground stores by pumping from deep wells is often attended with the lowering of the water-level over large areas, thus involving the loss of water in wells which had hitherto afforded the supply needed for domestic or trade purposes. Where water flows in a defined channel, as in a stream, or from a spring, its abstraction involves compensation to those who are entitled to utilise it. If, however, water flows through underground strata, the Courts have held that there is no legal title to it, as it cannot be identified. The inhabitants of a district may, therefore, be deprived of their water supply if their wells are on the before-mentioned cone of depression. By adding lithia to water, a very definite and well recognised effect is produced in the spectroscope, by which water *can* be identified, and the writer succeeded in doing so in a case where water was abstracted from a stream by laying drain-pipes in a field adjoining, and thus *enticing* (as it is termed) the water from the stream without compensating the riparian owners.

Temperature of Well Water. The temperature of water from wells and bore-holes is 52° F., at a depth of 100 ft.; 59° F. at a depth of 500 ft.; 68° F. at a depth of 1,000 ft.; 76° F. at a depth of 1,500 ft., and so increasing with the depth. For the supply of a town, a temperature of from 52° F. to 55° F. is desirable.

Classification of Wells. Wells are classed as (1) shallow wells, (2) subsoil wells, and (3) deep wells. The first, intended to supply adjoining wants, are always liable to pollution from surface water, derived from the houses, farms, or cultivated land. The second derive their supply from a greater depth, and pollution can be avoided if the well is built with brickwork in cement, surrounded by a layer of clay puddle, until it has been carried through the pervious surface soil, to prevent polluted water percolating to the level whence the supply is drawn. The top of the well should be carried a few feet above the ground, and covered. The third is sunk to reach water-bearing strata at a depth from the surface where the water would be free from organic pollution, unless, in very exceptional cases, a fissure in the strata brings polluted surface water to the deep-level water.

Artesian Well. An *artesian* well is one that is sunk to a source of supply which is fed by water flowing from a higher level than the top of the well, so that when the source is reached the water flows from the top of the well at a greater or less height, according to the head of water acting on the column. The size of the tube in this case governs the supply of water, as the quantity that can be discharged depends upon well-known hydraulic rules, the factors being the diameter, length, and roughness of the tube, and the head or pressure of water.

Tubbing. Cast-iron cylinders bolted up in segments and called *tubbing* are often employed as the lining of a large well. The first part of the cylinder has a cutting edge at the bottom of it, so that as the ground is excavated the cylinder sinks by the weight of the ironwork alone, aided, if necessary, by a temporary weight. A timber framing is used during the execution of the first 20 ft. of the work, to keep the cylinders vertical. If the work be in water-bearing strata, compressed air can be used to prevent the water rising and interfering with the men excavating, the well being made airtight for that purpose.

Wells Through Rock. In sinking large wells through rock, blasting has to be resorted to, on the *small shot* system, the object being to remove as much stuff with the fewest shots,

the holes for which are generally not drilled nearer to the side than about 12 in. As the air gets fouled at about 30 ft. below the surface, a change of air is necessary, and this is effected by carrying a tube down the side, attached to a fan on the surface.

Boring large wells through rock can be done by employing rods to which is attached a wrought-iron crosshead, with wrought-iron chisels, having steel points. This tool is raised by a cable, which is coiled round a drum on the surface, and which enables the tool to be lifted and dropped quickly. During the operation its position is changed by a rotary motion. If the boring be a small one, only a single chisel is used. The diamond drill [see page 2669] enables a solid core to be extracted.

Tube Wells. Tube wells are a convenient and cheap way of sinking through ground that is not rocky, to ascertain the level of underground water, and to obtain either a temporary supply (as for a camp), or a permanent supply. The method of carrying out the work is by driving tubes screwed together in lengths, the screwed joints keeping out surface water. As one length is driven, another is screwed to the top of it and the sinking proceeds, the driving power being obtained by dropping a weight from shear legs on the top, as in pile-driving. The material inside the tube is removed by a *shell pump*, or cylinder, divided into compartments, each having a valve through which the débris passes into the pump, which is smaller than the hole, and is lowered by a rope, and after being lifted and dropped a few times, it gets filled, when it is raised and emptied.

Storage and Impounding Reservoirs. We shall now consider the question of providing the water supply of a town by storing it in a reservoir of sufficient capacity to provide for the possible contingency of droughts. The supply may be either from a stream or from a river at a low level, involving the pumping of the water to a storage reservoir situated high enough to afford the necessary pressure to reach the highest parts of the district, or it may be by impounding the water in a river supplied from an adjoining watershed by the construction of a dam of earthwork, masonry, or concrete across the valley in which the river flows. To meet the requirements of the district it is essential that the capacity of the reservoir, governed by the height of the dam, and by the amount of water that can be impounded, should be sufficient to meet the exceptional needs of periods of drought. It is also necessary to make trial borings over the whole site of the proposed reservoir to ascertain that there are no strata through which the water can percolate and be lost underground. Levels must be taken across the valley and trial holes, or trial shafts, made along the line of the proposed embankment or dam, the line being settled upon these results.

Capacity for Reservoirs. In determining the capacity required for an impounding reservoir, the engineer has to consider what compensation has to be provided for those who have the legal right to the use of the water flowing in the stream either for agricultural or other riparian purposes, or for power in working mills by waterwheels or turbines. Although the users of streams are often benefited by the conservation of water in a storage reservoir, by which occasional floods lower down the river are prevented or mitigated, yet, in practice, the engineer has to deal with compensation water. To solve all the problems that have been indicated requires careful observation, skill, and experience.

In dealing with the conservation of water from gathering grounds the question of quality and purity, as well as of quantity, is a factor. These will be touched on later.

The better conservation of the rainfall of this country is a national question, and demands at this time careful consideration. The population increases, but the water which is available for their requirements does not increase, and every year there arises a struggle for watersheds from which to obtain the supply for the needs of the great communities centred in our towns, while the populations in villages too often depend upon shallow wells, which are liable to pollution. An ideal state of things would be realised had the whole country been mapped out into watershed districts under a Department of State, by which a careful study of the physical geography and of the hydrogeological conditions of the country would have led to a more equitable and systematic utilisation of the rainfall than has hitherto obtained. The rivers and watersheds could then have been utilised on some definite system to ensure the conservation of the water, and to avoid the appropriation of important gathering grounds for small purposes.

Storage of Flood Water. The utilisation of the excess water in wet seasons to meet the deficiencies in dry seasons can be accomplished only by the construction of impounding reservoirs, in which flood waters may be stored, with the double advantages of mitigating the effects of floods and of better adjusting the balance between supply and demand.

In considering the question of conserving flood water for town supply, flood water was, until recently, objected to, as it was under the ban of being polluted. The report of Lord Llandaff's Commission, in 1899, on London water removed this ban as it stated that "no restriction need be placed on taking flood waters," and also, "it would present a double advantage—the cost of pumping to store would be saved, and it would be possible to take much more water into the reservoir when the river is full, as the intake would not be limited by the capacity of the pumps, which cannot deal with more than a fraction of the water passing down at times of flood."

Continued

NON-COMMISSIONED OFFICERS

Channels to Promotion from the Ranks. Examinations for the Private. Technical Branches of the Service. Pay, Discharge, Pensions

By C. DUNCAN CROSS

LANCE-CORPORAL or acting bombardier is perhaps the most difficult position of any man in the Army, and for this reason. He is promoted from among his fellows, and exercises a certain limited authority over them. He must live among them, mess with them, and be one of them; yet all the time he must keep his authority intact. A very good use for his leisure hours will be attendance at the regimental school or private study to improve his education, for to-day war is a complicated thing, in which book knowledge has its place quite as much as physical strength. In any case, before being promoted to corporal or bombardier, the aspirant will have to gain a third-class certificate of education, if he does not already possess one. This is an easy examination which any intelligent boy should be able to pass. It consists of:

ARITHMETIC. Compound rules and reduction, simple vulgar fractions, and the ability to make up a messing account.

COMPOSITION of a letter to a friend.

WRITING FROM DICTATION. Extracts from Regimental Orders.

In this he must gain 120 marks out of a possible 200. As a corporal he will have to wait some time for his third stripe. The interval may very well be occupied in gaining a second-class certificate for:

ARITHMETIC. Reduction, practice, proportion, fractions, decimals, military percentages, averages and proportion, superficial and cube measures, ability to make up a pay and messing account for three, etc.

COMPOSITION. Ability to describe clearly any simple object, incident, or place in the candidate's acquaintance.

WRITING FROM DICTATION. Extracts from Regimental, Command, or Army Orders.

Sergeants. With a second-class certificate a man may be promoted to sergeant when a vacancy occurs. In addition he will have to pass a practical examination in the intricacies of drill and the interior economy of a company, squadron, or battery.

At the present time it is possible to rise to colour-sergeant, or the equivalent positions of troop sergeant-major and battery sergeant-major in Cavalry and Artillery, merely by waiting for seniority. But all signs point to the fact that in future a first-class certificate will be necessary; and this is a more serious affair.

ARITHMETIC. The whole subject (except present worth and discount, stocks and cube root). Prominence is given to problems.

COMPOSITION. The ability to write out in clear language the substance of a passage of English prose read out by the examiner.

MAP READING. A knowledge of the four cardinal and the four intermediate points of the compass; a knowledge of plain scales sufficient to measure distances on a map; a knowledge of the meaning of contour lines and coloured shadings on maps; and ability to draw the conventional signs used in field sketching.

ENGLISH HISTORY. From the year 1688, and a campaign or a biography.

GEOGRAPHY. Including a general knowledge of the size and position of the continents, oceans, and the countries of the world; detailed knowledge of the British Empire; a general knowledge of the movements of the earth, the variations of time, season, and climate.

A soldier holding a first-class certificate can be examined, at his desire, in any foreign language, in shorthand, or in typewriting (these two last being particularly useful to those engaged in clerical work), or in any of the following military subjects: (1) Military engineering, tactics, and topography; (2) military law; (3) administration, organisation, and equipment; (4) military history. The holding of the certificate is valuable, not only for the increase of pay which it carries, but also as a proof to his superior officers that he intends to succeed in his profession. For promotion to warrant rank it is essential.

Quartermasters. A post much sought after is that of quartermaster, which carries with it the rank of honorary lieutenant. To attain this the soldier must have branched off earlier in his career and have had something to do with the quartermaster's department—have become in time quartermaster-sergeant. Then, if he holds a first-class certificate and is not over forty years of age, his colonel may recommend him, on the occurrence of a vacancy, for quartermaster. In the Cavalry the post of ridingmaster bears an honorary commission and is obtained by corporals and sergeants after a course at Canterbury.

Another post of honour is that of sergeant-major. Our sergeant having been promoted to colour-sergeant, or its equivalent, must then wait with what patience he can for promotion, which, other things being equal, goes by seniority among the senior N.C.O.'s. To a good many men this appointment is the summit of their ambition, and they are content to serve on as warrant officers to complete their twenty-one years for a pension. To a few of those who desire it, comes the appointment of quartermaster, carrying with it the rank of honorary lieutenant.

Technical Branches. Of the technical branches the Royal Engineers is the most

popular. Men of the following trades are enlisted as sappers, and approximate in rank to infantry privates: Balloonists, blacksmiths, boatbuilders, boatmen, boilermakers, bricklayers, cabinetmakers, carpenters, coppersmiths, coopers, divers, electricians, engine drivers and makers, farriers and shoeingsmiths, fitters, gasfitters, harness makers, instrument repairers, joiners, masons, metal turners, moulders, painters, paperhangers, pattern makers, plasterers, plumbers, riveters, sawyers, shipwrights, slaters, tinsmiths, wheelwrights, whitesmiths, wood turners, and a few men of other trades such as architects, clerks, photographers, printers, tailors, telegraphists. Any man who is a good craftsman in these trades will find a niche in the Engineers. A few drivers are also required. Telegraphists and men conversant with railway work are welcomed in the Reserve.

Before being accepted the recruit has to satisfy the authorities that he is a good workman. This may be done either by producing a certificate from his employer or by trial in a military workshop. Men are rated and paid according to their abilities, and those whose trade qualifications do not come up to standard are classed as "labourers." On improvement they are promoted to a higher class of pay.

Pay for Engineers. It may be well to state briefly the system of payment in the Engineers. There are seven rates of Engineer pay, as follows:

			s.	d.	
1st Rate	..	..	2	0	per day
2nd ,,	..	..	1	8	,,
3rd ,,	..	..	1	4	,,
4th ,,	..	..	1	0	,,
5th ,,	..	..	0	8	,,
6th ,,	..	..	0	6	,,
7th ,,	..	..	0	4	,,

Every recruit on being dismissed from instruction in field works, or whatever branch of the Service he may be attached to, begins to earn Engineer pay at one of these rates in addition to his daily pay. Before he can be promoted the Engineer must be proficient at his trade, whether it be bridging, survey, telegraphy, or what not. He will find in this self-contained corps instructors of all sorts to assist him, and the smart man is soon picked out for promotion to acting corporal. From acting corporal he rises through second corporal to corporal, just as does the infantryman, and his work will increase in importance and interest as he goes on; till, on passing the educational examination outlined previously, and on giving proof of efficiency in his trade he reaches the rank first of sergeant, then of company sergeant-major, or of quartermaster-sergeant. He will find as he gets on that there are billets for warrant officers, such as instructorships at the depots, on the staffs of the regimental districts, and at the Record and Survey Department at the War Office, at home and abroad, that carry with them excellent pay. At the end of his service, too, he is nearly sure of obtaining employment a civilian capacity, thanks to the admirable aining he has received in the corps.

Army Service Corps. The Army Service Corps is another skilled corps to which tradesmen will naturally turn. Its duties are the supply of the Army with necessaries, and it therefore invites workmen belonging to the following trades: Bakers and confectioners, butchers, carpenters, clerks, coopers, farriers, saddlers and collar and harness makers, shoeing and jobbing smiths, tailors, engine drivers and makers, fitters, gasfitters, metal turners, moulders, plumbers, riveters, metal shipwrights, tinsmiths, and whitesmiths. When the men are accepted they must show their knowledge of their trade, and when they have completed their military training they are employed at their special trade as far as possible. Promotion is rapid, owing to the large proportion of N.C.O.'s required for responsible positions in the corps, and at the end of their period of service employment is generally not far to seek.

Army Ordnance Corps. In the Army Ordnance Corps there are wanted carriage smiths, clerks, collar makers, coopers, fitters, labourers, saddlers, sail makers, smiths, and wheelers. After three months' drill and instruction those who pass the trade test are employed at their particular calling. The corps is a small one, whose duties are the provision of arms and ammunition, equipment, stores for barracks, etc., and the repair of articles returned to store. Since over 40 per cent. are warrant or non-commissioned officers, it will be seen that the opportunities to the skilled man are very great. The armourer section forms a notable feature of the corps. To enter it a man must be a qualified gunsmith, and after undergoing a course at the small arms factory he is promoted at a bound to armourer-sergeant, and generally attached to a body of troops to take charge of the arms and their repair. The machinery artificer section consists of qualified fitters and watchmakers, whose duties are the examination and repair of gun mountings and instruments. Candidates for this section on giving proof of their expertness are promoted immediately on enlistment.

There is no prospect of rising beyond the rank of warrant officer, but the pay of the corps is so good that it attracts many skilled men who prefer the certainty of the Army to the uncertainties of civil life.

Medical Corps. The Royal Army Medical Corps is for the care of the wounded in the field and for the care of the sick in peace time. For men who have a liking for the work there are good openings, inasmuch as there is a very large proportion of N.C.O.'s to privates—about one in four. After being dismissed from the preliminary instruction recruits are posted to the various branches of the corps—to the nursing, clerical, cooking, or general staff, where they learn the duties they will have to carry out in the field. In addition to the regimental pay there is corps pay, corresponding to the "Engineer pay." On being reported qualified in their duties recruits begin to draw their corps pay, ranging from 5th rate for third-class orderlies of the nursing section

and privates of the general duty section (4d. per day) to 1st rate for sergeants and lance-sergeants of the nursing and cooking sections (1s. per day). The work in peace time is light but unexciting, and since promotion is rapid, there is a steady flow of recruits to the corps. On retirement there is a good chance of obtaining employment in hospitals, asylums, prisons, and other public institutions. There is, however, no chance of rising above warrant rank. The regimental pay is slightly better than that of the Infantry of the Line, ranging from 1s. 2d. per day for a private on enlistment to 2s. 8d. per day for a sergeant. Quartermaster-sergeants get 4s. 6d. per day.

Boys. A small number of boys are required in the Army for service as buglers, trumpeters, drummers or musicians. They must be between 14 and 16 (unless from the Gordon Boys' Home, where they have been trained as musicians or in some trade; or boys for the Royal Artillery, when the age limit is extended to 17), and the consent of a parent or guardian is necessary. At the age of 18 they become available for service in the ranks, and proceed as do other soldiers.

Discharge and Pensions. Should a soldier within three months of his joining the Army desire to leave the Army, he may purchase his discharge for a payment of £10. After that time it will cost him £18. Should he have served three years and have been transferred to the Army Reserve the sum increases to £25.

At the end of 12 years' service with the Army and the Reserve a man is given a free discharge with a gratuity of £1 for every year served, with a maximum gratuity of £12. But the soldier whom we have been advising will re-engage after 12 years for another nine years to complete his time for a pension, and on leaving he receives a pension according to his rank and the length of time he held it before discharge. Warrant officers and non-commissioned officers are divided into classes according to the time served in their rank and their qualifications: Warrant officers, 3s. to 5s. a day; non-commissioned officers, 1s. 3d. to 3s. 6d. per day; and privates, 8d. to 1s. 6d. per day. Service beyond 21 years brings with it 1d. a day for the higher classes and ½d. a day for the lower classes, with a maximum addition of 9d. and 5d. respectively. For wounds or injuries contracted in the country's service pensions are given on the man's discharge, varying between 6d. and 3s. 6d. a day, according to rank and the extent of the injury. Good conduct medals carry with them a gratuity of £5 on discharge, and the Victoria Cross a pension of £10 a year. An important question before a man nearing the end of his service is: "What can I do when I return to civil life?" For a really good man who has been popular with his officers there is often some position of trust to be obtained by his commanding officer's influence. Should this privileged avenue fail, Government employment is offered to discharged soldiers in the Post Office, the Royal Arsenal, Army Clothing and other Government departments. The police force, the Commissionaires, and the staff of Park Rangers are also favourite outlets for ex-soldiers. There is a National Association for the Employment of Reserve and Discharged Soldiers, where men may register their names for civil employment, and it is evident that the matter will shortly be taken in hand by the Government by teaching men a useful trade during their period of service in the Army, and by ear-marking certain Government appointments for ex-soldiers and sailors. In any case a thrifty man should be able to save, after he begins to draw service pay, not less than 6s. a week, which, with interest at the rate of 2½ per cent., will amount at the end of his 21 years to nearly £400—a very useful asset with which to purchase a business or set himself up in trade.

Pensions for Widows. Lastly, pensions are granted to widows and children of N.C.O.'s and men who have died of wounds or injuries received in the execution of their duty. These vary between 5s. and 10s. a week for the wife, and 1s. 6d. to 2s. for each child, according to the rank of the husband. For the orphans of soldiers and a few other deserving cases there exist the Duke of York's Military School and the Royal Hibernian Military School, where boys are educated free of charge. The future of these boys is provided for by the authorities, who at the expiration of their school life will either apprentice them to trades or allow them to join the Army. Among the best men in the Army are to be found boys who were brought up at these admirable institutions.

Continued

MILK AND ITS PRODUCTS

Weight and Constituents of Milk. Cleaning, Sterilising, and Pasteurising. Composition of Cream, Separated Milk, Whey, and Buttermilk. Analysis

continued from page 3893

By Professor JAMES LONG

NO article of food has been subjected to so much criticism or to such searching examination as milk; and yet we have much more to learn about it, especially as to its behaviour in relation to fermentation, to the manufacture of cheese and butter, and to digestibility. Although a fluid, it contains food in the form of fat, which is the chief constituent of butter, sugar, casein (a most important albuminoid), and various mineral matters. Its average composition is as follows:

Constituent.	Average Quality.	Low Quality.	High Quality.
*Fat	3·35	2·50	6·91
Casein and Albumin	3·45	3·04	3·48
Sugar	4·83	4·90	5·02
Mineral matter	·72	·66	·72
Water	87·65	88·90	83·87
	100·00	100·00	100·00

* This and subsequent tables are from "Elements of Dairy Farming," by James Long.

If, however, we take the estimates and average analyses of various British and foreign authorities, the average fat percentage reaches 3·7, and the solids other than fat, 9 per cent.

Colour. Milk varies in *colour* in accordance with the breed or individuality of the cows producing it. The Jerseys and Guernseys of the Channel Islands, the South Devon cows, and cattle of similar types in France and Denmark produce milk of richer colour than the majority of native breeds, this colour being due to the globules of fat which are held in suspension, and which, when removed, leave the fluid white. If, however, the casein or curdy matter be also removed, as in the cheese dairy, the whey, which is the liquid remaining, is of a greenish yellow colour, containing nothing but sugar and the mineral matter.

Solids. The solid matter in milk is held partly in suspension and partly in solution, the proportions, as defined by the eminent French chemist Duclaux, being as follow in milk of very poor quality:

Solids.	In Suspension.	In Solution.
	Per cent.	Per cent.
Fat	2·75	—
Sugar	—	5·38
*Casein (and albumin)	2·72	·55
Phosphate of Lime	·21	·14
Soluble Salts	—	·35

* Duclaux includes all nitrogenous matter under this term.

We have stated that the colour of milk varies with the breed; the remark equally applies to its quality. It varies also in accordance with the age of the cow, with the time which divides each milking, with the date which has elapsed since the cow calved, with the condition of her health, and whether or not she be in a state of excitement. The first milk drawn, too, is much poorer in quality than the last milk, hence the importance of thoroughness in milking. It is for this reason that the owners of many herds cause each cow to be stripped after the milker has completed his work, thus:

	Fat.	Solids.	Water.
	Per cent.	Per cent.	Per cent.
First milk	1·32	11·83	88·17
Strippings	9·63	19·18	80·82
First quart	1·22	10·82	89·18
Last quart	8·48	17·24	82·76

Colostrum. Whatever may be the quality of the milk of the individual cow, or the difference between the various cows in a herd, the composition of the milk of mixed herds is very similar, owing to the fact that the milk of each cow is mixed before it is despatched to the purchaser. The first milk yielded by a cow after she has produced her calf, and known as *colostrum*, is poor in fat but extremely rich in casein and albumin, which is present in all milk but usually included under the term casein.

COMPOSITION OF COLOSTRUM (WARINGTON)

	Per cent.
Water	71·7
Fat	3·4
Casein and other albuminoids	20·7
Sugar	3·2
Mineral matter	1·1
	100·1

Morning and Evening Milk Compared. As the cow, however, progresses and becomes stale—namely, as she approaches the time of drying—her yield diminishes in quantity but sensibly increases in quality. It is believed, too, that with the increase in age, especially after a cow has reached six years, her milk increases in quality, but facts do not fully warrant any statement being made as to its general application. When a cow is milked every twelve hours the milk she produces is practically identical in quality; but where the afternoon or evening milking is—as is the case in this country—from seven to nine hours after the morning milking, the quality is sensibly increased in the evening, and as sensibly diminished in the morning. The evening milk is, therefore, weight for weight, much more valuable than the morning milk.

Influence of Food. The influence of food on the quality and value of milk is not fully recognised. Producers, as a rule, believe that they can improve the fat contents by high feeding; but this is not borne out in practice,

while it is distinctly in opposition to scientific teaching. Farmers have observed that in changing a herd from one pasture to another there is an almost immediate and beneficial result. But that result is chiefly in the direction of an increased quantity, and the reason is obvious: the cows are removed from grass which has been practically eaten close to the soil on to a field which is fresh, sweet, and perhaps carrying abundant herbage.

Value of Fresh Pastures. Apart from this, however, the mere *change* from a stale to a fresh pasture encourages secretion. And so it is, where the cows are stalled, when they receive an increase in their ration of cake, meal, grains, bran, or some similarly palatable food. When a cow is receiving a full ration—that is, as much as she can properly assimilate—no addition, either of quantity or quality of food, will enable her to produce milk of superior quality; but when she is under-fed there is every reason to believe that any addition to her ration is followed not only by an increase in the quantity but an increase in the quality.

Again, it is obvious that much depends on the health of the cow. If her system be disturbed, not only is the quantity diminished, but the quality suffers, and so far as has been observed a diminution in quantity means a diminution in the fat percentage. The following instances of two cows suffering from pleuro-pneumonia may be quoted to emphasise this:

	Per cent.	Per cent.
Water	89·60	89·18
Fat	1·18	1·30
Sugar	4·40	4·50
Casein	4·16	4·38
Mineral matter	0·66	0·64
	100·00	100·00

Cooling and Aerating. It is important that milk should be *aerated*, and if intended for sale, *cooled* as soon as it is drawn. The modern system of cooling, by means of either the *horizontal* or the *lenticular cooler*, figured and described in the next lesson, provides complete aeration by which the cow-like odour of the milk is removed. Where milk is placed in a vessel, and especially if it be covered with a lid, without cooling or aerating, its disagreeable odour is largely retained. The exposure of milk to any pungent smell should always be avoided, as it possesses a property of absorption which may render it almost unfit for use, or even for conversion into butter.

Specific Gravity. The density or *specific gravity* of milk varies in accordance with its quality; but to ascertain its density by direct weighing is impossible except in skilled hands and by the aid of the delicate instruments of the laboratory. Specific gravity is taken for all ordinary purposes by the aid of an instrument known as the *lactometer*, but it is important that the temperature should be observed, inasmuch as milk expands with heat. A gallon of pure water weighs 10 lb. at 60 degrees F., when the barometer stands at 30 in. Under similar conditions milk may weigh from 10·27 to 10·34 lb. per gallon, its specific gravity, by altering the decimal point, thus being 1·027 to 1·034, figures which may be regarded as the limits. Although it is quite possible that while pure milk may possess a density represented by either of these extremes, yet the probability is that it is watered or skimmed. Obviously the fat globules of milk are lighter than the water of milk which, as we have seen, forms some 87·5 per cent. of its composition; but the remaining constituents—the minerals, the casein and the sugar—are heavier. If, therefore, we remove the cream, which contains practically all the fat, the density of the milk is raised; whereas, if we add cream to pure milk it is reduced. The reason why milk is slightly heavier than water is due to the fact that the sugar, casein and mineral matter, owing to their larger quantity, influence it more than the fat. Again, if water be added to milk, its specific gravity is reduced; thus, milk with a low specific gravity is usually regarded as watered milk. If we take a pure sample and assume that its specific gravity is 1·031, the figure will be increased by the removal of the cream. If we add 10 per cent. of water, the density will be reduced to 1·029, and still further reduced point by point until, when 50 per cent. of water is added, its density stands at 1·016.

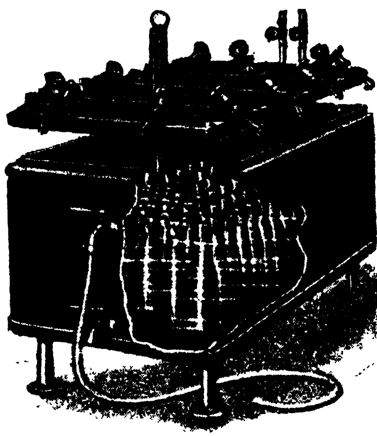
Testing for Adulteration. One of the common practices of the day is the addition of separated or skimmed milk to new or whole milk. As by the Government standard milk offered for sale must contain 3 per cent. of fat, it follows that a vendor can dilute a rich sample—one which, for example, contains 3·7 per cent. of fat—with separated milk and still remain on the right side of the law, although the practice, if known, would subject him to prosecution. If we assume that pure milk of good quality varies from 1·029 to 1·032, neither of which figures are extreme, there is reason to suspect its purity if it falls below the former or is raised higher than the latter figure. A high specific gravity—1·034, for example—suggests the addition of separated milk. It is important in testing with the lactometer to obtain a table which is frequently sold with the instrument in order that whatever its temperature when tested, its actual specific gravity may be recognised by reference to the figures. Just as milk expands with a rising temperature, so it contracts as the temperature falls; but this contraction ceases at about 4° C., below which expansion again begins.

The German expert Fleischman has shown how the constituents of milk are divided in the process of butter and cheese making. His figures are extremely valuable and are as follows:

Substance.	Water.	Fat.	Casein, etc.	Sugar.	Ash.
Whey	78·9	3·2	22·3	76·6	60·3
Buttermilk	14·0	2·3	13·8	11·2	12·5
Skim Cheese	3·6	11·5	61·5	4·2	26·7
Butter	·6	81·5	·6	·2	·5
The Loss	2·9	1·5	1·8	7·8	—
	100	100	100	100	100

It should be pointed out, however, that in the manufacture of skim cheese a larger quantity of fat is left in the skimmed milk than under other conditions.

The Fat in Milk. If a drop of milk be placed beneath the microscope, the field will be covered with a large number of tiny globules somewhat evenly distributed, although somewhat irregular in size, especially in the milk of Channel Islands cattle. A drop of the last milk drawn from the cow at milking time will contain a much larger number of these globules than a drop of the first, or *fore* milk, while the latter will contain still more than are seen to be present in a drop of *skimmed* milk. Fat globules of average size measure about $\frac{1}{5000}$ of an inch in diameter, but the largest globules are about $\frac{1}{1500}$, and the smallest $\frac{1}{12000}$ of an inch. The number of globules present in a cubic millimetre ($\frac{1}{1000}$ of an inch) has been estimated at from a million to $3\frac{3}{4}$ millions. The fat of milk, which is represented by these globules, chiefly consists of *olein, stearin, palmitin, butyrin, caproin,* and *caprylin,* palmitin and stearin being regarded as solid fats, and the remainder as liquid fats or oils. The constituents butyrin, caproin, and caprylin in their corresponding form of fatty acids are volatile. If we take the average size of the fat globule of the Guernsey and Jersey cow at 100, and its diameter at $\frac{1}{9000}$ of an inch, the size of the globule in other milks will be found to vary from 110 to 133, and the diameter from $\frac{1}{10000}$ to $\frac{1}{12000}$ of an inch.



17. MILK STERILISER

Size and Number of Globules of Fat. In an investigation in which the milk of 15 cows of six different breeds was submitted to 150 examinations it was found that the number of globules of fat produced by the average animal was about 136,000,000 per second. The size of the globule exerts an important influence on the success of a butter dairy. The larger the globule the quicker it rises to the surface where milk is set for cream, while the smaller the globule the longer the delay, and therefore the greater the difficulty in reaching the surface—a difficulty which becomes impossible when, owing to such delay in warm weather, acidity commences, the milk is coagulated, and the passage upwards blocked. The fats of which the globule is composed are in no case constant in quantity—especially varying with the temperature and probably with the food consumed. In winter the solid fats are larger in proportion, and the food smaller, while the volatile fatty acids frequently vary as winter approaches to such an extent that pure butter has, upon analysis, frequently been condemned as margarine owing to the similarity in its composition to that imitation in this particular aspect. Agreeable as milk fat is to the palate, its odour and flavour are rapidly changed by exposure to light and air. This change is believed to be due to the decomposition of the glycerides of the volatile fatty acids, which is retarded by the aid of salt and various chemical preservatives—which, however, should never be used. Decomposition is retarded by the skilful removal of all foreign matter in the manufacture of butter, especially of the sugar and casein, which, present in the cream, find their way into imperfectly made butter.

The Sugar of Milk. This is one of its most constant solids, and the one which, in the process of cheesemaking almost entirely remains in the whey. It is composed of carbon and the elements of water as follows:

Carbon	40·00
Hydrogen	6·66
Oxygen	53·34
Total	100·00

Sugar of milk does not ferment so easily as cane sugar. It can be obtained from milk by the evaporation of the fluid in which it is in solution after the extraction of the casein and fat. In its pure state it keeps well, and is soluble in hot water or in five to six parts of cold water. [See the lessons on Sugar in FOOD SUPPLY.]

The Casein of Milk. The albuminoid matter of milk, which includes albumin, is usually described by this term. The following figures represent the composition of casein:

Carbon	53·83
Oxygen	22·52
Hydrogen	7·15
Nitrogen	15·65
Sulphur	A trace

Although casein can be precipitated by various acids, including the lactic acid of milk itself, which causes spontaneous coagulation or curdling, it is in the process of cheesemaking coagulated by rennet, to which reference is made in a subsequent lesson. Casein is one of the three important constituents of cheese, of which it forms about one-third. It is present in cream in small quantities, but should be entirely absent from butter, in which, as it decomposes, it causes a disagreeable flavour and odour. The albumin of milk, unlike the casein, is not precipitated by rennet, but by heat; hence the practice of many cheesemakers of *cooking* the curd, as it is termed—that is, heating it to an unusually high temperature. The albumin of milk is believed to form about one-sixth part of its albuminoid matter.

The Mineral Matter or Ash of Milk. This is utilised in the animal economy in building up the body and other structures of the body of which minerals form part. It is extracted from the soil by plants, and

conveyed by them in the form of food to the cow. Average milk contains about 0·7 per cent. of mineral matter, usually described as ash, for the reason that when the solid matter of milk is burnt the minerals remain in that form. The chief mineral constituents of milk are *potash, lime, phosphoric anhydride*, which forms about one-third of its total weight, *chlorine, soda, and magnesia.* Where milk is sold the loss of fertile matter to the soil from which the cows are fed in the course of a year is considerable, owing to the removal of the nitrogen in the casein, and the potash and phosphate of lime in the ash. These three materials, as we have shown in dealing with the science of manuring [pages 433-4], form the three cardinal constituents of the soil, and those which are essential for the growth of crops. Where, however, cows are fed upon purchased cake or corn, and especially where, in addition, artificial manures are employed, the loss through the medium of the milk may be ignored, that loss being variously placed at from 20s. to 25s. per cow per annum.

Bacteria in Milk. The maintenance of the sweetness of milk is almost as important as its purity. Milk changes with great rapidity during hot weather, and at all times acidity is induced by the presence of organisms known as *bacteria.* The organism chiefly concerned in the production of acidity in milk is known as *Bacterium lactis*, which is chiefly derived from air, and which is abundant in dairies, milk shops, cow-houses, and other apartments in which milk is produced or handled. The organism chiefly feeds upon the albuminoids of milk, and by its action converts the sugar of milk into lactic acid. The lactic bacterium, however, is not the only organism found in milk ; there are others which are equally responsible for fermentation or chemical changes, not only in the milk itself but in the butter and cheese produced from it, and among these may be mentioned the butyric ferment (*Bacillus butyricus*) which is the cause of rancidity in butter. Other forms of bacteria are occasionally found, including the organisms responsible for tuberculosis and other serious diseases ; but where ordinary care is taken, or where milk is boiled or sterilised, the presence of these germs need not be feared.

Why Cheese Ripens. Milk also contains a variety of unorganised ferments, some of which are responsible for the ripening and flavour of cheese, and of moulds. Among the former may be mentioned *galactose*, an enzyme and digestive ferment, which was discovered by Drs. Badcock and Russell, said to resemble a secretion of the pancreas of animals. To this enzyme the discoverers largely attribute the ripening of cheese, which they contend may now be cured by its aid at a low temperature, thus rendering the old-fashioned cheese-rooms and the maintenance of a high temperature unnecessary. In Great Britain, however, the old system is still in force, and is likely to remain so until more is known of the new discovery.

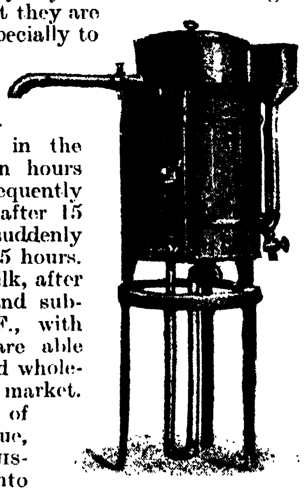
Multiplication of Bacteria. The bacteria of which we have spoken are single-celled members of the vegetable world, seldom exceeding 10 μ. (μ. = ·001 millimetre in diameter). The multiplication of these organisms is extraordinarily rapid ; in a humid atmosphere, and at a temperature of from 86° F. to 104° F., the cells divide in from 15 minutes to an hour, so that at the latter temperature a single cell may become millions in a day of 24 hours. Before its extraction from the udder of the cow, milk is germ free, but immediately it is exposed to the atmosphere it is attacked by bacteria, especially in the cattle-house, where they abound—hence the importance of milking, if possible, in the open air. Harwood records that in a test made at the Maryland Station 7,000 bacteria were found in a cubic centimetre of milk (about a quarter of a spoonful) ; while after standing in water for 15 hours at 60° F., 2½ millions were found. When 24 hours had elapsed, the number had reached 69 millions, while at the end of 39 hours there were no less than 300 millions.

Bacteria are Good Servants but Bad Masters. Although there are bacteria which are useful to man, it is incontestable that where, owing to imperfect conditions, these increase rapidly, they become extremely deleterious in their turn, and render milk unfit for food. When the temperature of milk is reduced, the rapidity of reproduction diminishes, and it is for this reason that dairymen require the farmer to cool the milk down to 50° F., when reproduction is practically checked, to be increased, however, immediately the temperature rises. Facts similar to those recorded by Harwood have been laid down by experimenters like Knopf, Miguel, and Freudenreich, in whose laboratory in Berne we have been enabled to see something of this particular work. The researches of Dr. Newman, who has repeatedly taken samples in London boroughs, many of which were unfit for human food, entirely confirm the results in the laboratory. When milk is coagulated, the growth of bacteria is checked ; this is believed to be in large measure owing to the acid which they produce—in a word, their multiplication is stopped by the accumulation of the products of their own growth. While bacteria are harmful when allowed to obtain the mastery, they are the valued servants of the butter and cheese maker who keeps them under control.

Sterilisation. The lactic bacterium is from 1·3 μ. to 1·6 μ in width, while in length it is about 1½ times its breadth. It is destroyed when the milk is boiled, but its spores or seeds, which are believed to resist heat up to 245° F., are practically killed when submitted to boiling point for half an hour. This, at all events, appears to be the result of the practice called milk sterilisation. Lister has demonstrated that where sterile milk is drawn from the cow into a sterilised bottle, and contact with air prevented, and if the bottle be hermetically sealed, it will keep. Milk, however, is now in daily practice sterilised by submission to heat at 212° F. for half an hour. The milk is first cleaned in the centrifugal separator, from which the cream tube is removed ; as it revolves, the dirt, the bacteria and other impurities are thrown to the sides of the vessel, where they form a somewhat

disgusting scum. It is subsequently passed into bottles, placed in the steriliser, with the stoppers loose, submitted to the required heat, when the stoppers are closed by a gloved hand in the live steam, so that the entrance of fresh germs from the air is prevented [17]. Milk prepared in this way may be delivered to customers by the dozen, or by a week's or fortnight's supply according to arrangement.

Pasteurisation. Pasteurisation [18] differs from sterilisation inasmuch as the milk is submitted to a lower temperature—175° F.—by which the bacteria are destroyed but not the spores. Coagulation of milk does not take place until from 7 per cent. to 8 per cent. of lactic acid has been produced. If before this quantity be present the acid is neutralised by the addition of an alkali, coagulation is postponed; but neither alkaline nor other so-called milk preservatives should in any case be used. Although the opinions of experts differ as to the influence of these materials, the majority of medical opinions is to the effect that they are deleterious to health, and especially to children and invalids. Pasteurised milk will keep longer than raw milk. When Fjord heated separated milk (a portion of which was boiled in the month of June after seven hours of exposure) to 158° F., subsequently cooling it slowly, it boiled after 15 hours' exposure; when suddenly cooled to 77° F., it kept for 35 hours. In factories, the separated milk, after skimming, is Pasteurised, and subsequently cooled to 50° F., with such results that farmers are able to take it home for use, and wholesale buyers to place it on the market.



18. MILK PASTEURISER

If the lactic fermentation of milk be permitted to continue, *butyric acid* is formed [see CHEMISTRY, page 3273]. *Lactic acid*, into which the sugar of milk is changed during fermentation, and as the result of the activity of the lactic bacteria, is composed of the same elements as the sugar itself, but the value of the milk as a food is entirely changed.

Cream. Cream is a milk product which possesses no definite standard. It may be thin or thick when removed from the milk; its thickness depends partly upon temperature, partly upon the presence of acid, and partly upon the quality of the milk and the system of skimming or setting adopted. By the aid of the *separator*, it can be removed as thin cream—which means that it contains more of the milk serum. If set at a low temperature, and if the milk be cooled before it is set, the cream will be thin. Cream cooled on ice, or slightly heated, will become thicker. In the latter case its apparently more substantial character is owing to the presence of acid and the slight coagulation of the casein. Very rich cream may contain only one-third of its weight of water, while very thin cream may contain two-thirds.

Devonshire Cream. Clotted cream, as made in the West of England, contains some 60 per cent. of fat and 33 per cent. of water, with approximately 5 per cent. of casein. Commercial cream is frequently preserved by the aid of chemical preservatives, for which reason it is a less desirable food. If milk be set in open vessels with a depth of 5 in. to 6 in. for 12 to 24 hours for the cream to rise, and the whole be then scalded to 170° F., there is slight coagulation—in such a case the cream becomes *clotted*. In this form it is not only highly appreciated on the table, but keeps longer. The remark applies equally to the milk serum remaining, and to the butter produced from the cream itself.

The Separator. If cream of 10 per cent. quality be removed by separation, that quality should be high. At wholesale price, 100 lb. of milk, or 10 gallons, would cost during the six months April to October, 6s. 3d.; so that one gallon of cream costs 1s. 6¾d. per quart plus the cost of separation. Such cream, however, is commonly sold by retailers at 4s. a quart, or 6d. a reputed quarter pint jar, which is equal to 4s. a reputed quart. Naturally, thick cream is frequently purchased, however, and thinned by the addition of milk before retailing. Where cream is removed by the separator, the quantity of fat left in the milk seldom exceeds 0·2 per cent.; but where it is skimmed from the milk which has been set in open vessels the fat remaining may reach one third of its total contents.

Why Cream Rises. The rising of cream is due to its lower density, that density varying from 1·000 to 1·016, so that, while it is lighter than milk, it is heavier than water. The practice of estimating the quality of milk by the aid of a *creamometer* is fallacious; this is owing in part to the temperature of the atmosphere, and in part to the individuality of the cows producing it. A tube in which milk is set may throw up cream of a high percentage, while the milk itself may be actually poor in fat. On the other hand, the percentage of cream may be low, and the fat yield high. Many examples may be taken from tests in the Government laboratories, and in our own practice, but we select two; in one case the cream percentage was 17·5, and the fat percentage only 2·5; in another the cream percentage was 4·5, and the fat percentage 4·57. Cream may be *pasteurised* for the improvement of its keeping properties, or it may be *separated* for the improvement of its quality.

Separated or Skimmed Milk. Separated or skimmed milk is that from which the cream has been removed, the first-named by the machine, the second by hand skimming. Its food value is practically maintained as equal to full milk by the addition of digestible fats or oils equivalent to the fat removed in the cream.

Skimmed milk of average quality is composed as follows :

	Per cent.
Water	90·10
Fat	·75
Casein	3·50
Sugar	4·85
Ash	·80
	100·00

The density of skimmed milk varies between 1·033 and 1·037. If 10 per cent of water be added the gravity is reduced to 1·032, so that it then compares on this basis very closely with full milk. Separated milk possesses a slightly higher specific gravity than whole milk, containing as we have seen less fat. If skilfully mixed with rich full milk of low specific gravity it may be passed for whole milk without detection.

Butter Milk. Butter milk is the by-product left after churning cream or milk from which butter fat has been removed. The quantity of butter milk produced depends upon the quality of the cream. As cream is churned in a mature, ripe or acid condition, buttermilk is acid, but it is a sound and wholesome food. The composition of an average sample is as follows :

	Per cent.
Water	91·2
Fat	·6
Casein	3·5
Sugar	4·0
Ash	·7
	100·0

Whey. Whey is the liquid by-product of cheese-making. In skilful hands it contains but little fat, although large cheesemakers remove this fat by skimming for the manufacture of whey butter. Whey, however, is chiefly supplied to pigs, its value depending upon the large quantity of sugar which it contains. In an average sample the sugar present reaches 5 per cent., the curdy matter 1 per cent., the fat ·35 per cent., and the mineral matter ·76 per cent.

Milk Testing. The quality of milk is tested in various ways ; by chemical analysis, by the Babcock and Gerber machines, the lactometer and the creamometer. There are other methods which require technical skill, but in practice the amateur now depends chiefly upon the two first named. By *chemical analysis* the water is driven from the milk by heat, the dry matter remaining being the milk solids, which are separately determined. The method of determination, however, belongs to the department of chemistry [see the course on CHEMISTRY, page 3820]. The *creamometer* [19] is a glass tubular or cylindrical vessel 10 in. high by 1½ in. in diameter, although smaller and consequently less reliable tubes are sometimes used. There should be a scale on the upper portion of the vessel divided into 100 parts, commencing with zero near the top. The milk is poured up to this mark when quite fresh, and kept for 24 hours at an even temperature, as near 60° F. as possible ; in due course the cream will rise, and the percentage can be read upon the scale. This test, however, as we have already shown, is not of a thoroughly reliable character.

19. CREAMOMETER

The Lactometer. The *lactometer* should always be used in conjunction with the creamometer where that vessel is employed. This instrument is usually adjusted for use at 60° F. If gently introduced into milk at this temperature the specific gravity will be shown. Thus, if the scale on the stem be level with the surface of the milk at the figure 30, the specific gravity is 1·030 ; but if the temperature be higher or lower, the specific gravity indicated will be higher or lower ; the indication, however, will not be correct, and therefore a correction scale is necessary, in order that the exact gravity may be ascertained by referring to it. The best lactometers are fragile, the stem not exceeding ¼ in. in diameter, and the bulb 1¼ in. by 3 in. in length. The most perfect lactometer is that invented by Quevenne.

The Babcock and Gerber Machines. The instruments invented by Babcock and Gerber are intended to determine the quality of milk by the extraction of its fat. The Babcock machine is a disc which revolves at great rapidity. Carefully measured quantities of milk are passed from a pipette into small bottles, the necks of which are graduated. These bottles are submitted to centrifugal force, when, by the aid of sulphuric acid, the casein of the milk being held in solution, the fat is driven into the neck of the bottle, and its percentage there read off. These machines are now generally used by advanced dairymen, and are of great value to the milk industry. The method of making the test, if the instructions sent with each machine be followed, is easily mastered. A number of samples of milk can be tested at one and the same time. Cream, buttermilk, skimmed milk, and whey may be tested by the same method. In some instances, especially in factories, samples of milk are daily kept and mixed with an appropriate antiseptic, the mixed or composite sample being tested weekly. As it is necessary, in order to avoid prosecution, that all milk sold should contain 3 per cent. of fat, it is not only important to dairymen but to farmers that milk should be frequently tested.

Continued

MORE ABOUT TIMBER JOINTS

Half-lap Joints. Tenon and Mortise Joints. Marking Out and Cutting. Other Varieties of Joints

CARPENTRY continued from page 3848

By WILLIAM J. HORNER

The Half-lap Joint. This joint is also called the *halved* joint and *lap* joint, though the latter term applies equally to pieces which merely cross each other and are screwed or bolted together [192]. Examples of half-lap joints are shown in **143** to **150**. One-half the thickness of each piece is cut away, so that the timbers join in the same plane, the combined thickness at the lapping joint being the same as that of each separate timber. This joint is used chiefly for uniting narrow pieces either when they cross, or meet each other at right or other angles, or for joining them end to end. It is neater and stronger than a joint which is merely lapped, like **192**, but it is neither neat enough nor strong enough for all purposes. It would never do, for instance, to make a half-lap joint in the middle of a beam or post, thereby diminishing its strength by one half; but, where only the ends of timbers are halved, their strength is not diminished much, and for many purposes there is no objection on the score of loss of strength to halving intermediate parts.

These joints are marked with square and gauge, sawn nearly to the lines, and finished exactly to the lines with rebate plane and chisel, the rebate plane being used because its iron cuts right out to the sides of the plane, and so can remove shavings up to the shoulder of the halving.

Modifications of Plain Half-lap. These consist in cutting one or both sides in the form of a dovetail, or V-shaped [**147** to **150**] bevelling, or dovetailing the face [**149**], mitring a corner [**189**], or making notches, tusks, or other variations calculated to enable the joint to withstand better the particular stresses of the structure. Strictly speaking, a half-lap joint is one in which both timbers are of the same thickness, and exactly half of each is cut away to bring their faces flush at the joint. There are many cases, however, where, though the lap is of the same character, it is not halved. Sometimes it is found best to cut less than half from either or both timbers, or only one may be cut for some portion of its thickness and the other left whole. Often, also, the thickness of the two timbers is dissimilar, and they may or may not have to be made flush with each other on one face. Halved joints are usually screwed together. In rough work they might be nailed, and in large work bolted.

Tenoned, or Mortise & Tenon Joint. This is the joint most commonly employed in framed work. It can be used in much the same circumstances as the half-lap, but being both stronger and neater than the latter it is generally preferred, except in cases where the extra work involved in making it is objectionable, or where the members could not be put together without cutting chase mortises —that is, mortises which permit the tenon to be slipped in sideways [**167**].

In the mortise and tenon joint the tenon is the projecting tongue, and the mortise the slot which receives it. Examples of these joints are shown in **151**, **152**, **154**, **156**, and others. There are two main varieties: those in which the mortise is cut entirely through the member, the tenon on the other member coming through flush with the outside, so that its end is always visible [**151**, **152**, **154** and **156**]; and the stub or stump tenon which does not go through, but fits into a correspondingly short mortise [**155** and **183**], and consequently does not show anywhere on the outer faces of the work when the members are put together. Both of these types are popular, circumstances deciding which is the more suitable.

Fixing Tenoned Joints. Tenoned joints are held together by being glued and wedged, or by driving wood pins or pegs through from one side, thus holding the parts together. Screws or nails are sometimes used instead of wood pins; and in heavy work, bolts. Gluing and wedging is generally more suitable for light and neat work. When pins are used, drawboring is practised to help to keep the parts together. In large joints held in this way, glue is not always used.

When a through mortise and tenon joint is to be wedged, the mortise is increased in width at the outer face to allow for the thickness of the wedges [**151** and **152**]. This, provided the glue holds the wedges to the tenon, really makes a dovetailed joint which cannot be pulled apart. Generally, two wedges are used, one on each side of the tenon, as shown in **151**; but sometimes wedges are driven into the tenon itself, splitting and spreading it, saw cuts, or a nick with a chisel being first made to start the wedges into. Fig. **154** shows what is considered the most substantial method of wedging, but it is not always employed, because of the trouble of making saw cuts the entire length of the tenon, as shown. Wedges inserted at an angle in this way never come out. Stub tenons also are often wedged, but in their case the wedges cannot be driven from the outside after the tenon is in place, and so their thin ends have to be inserted in the tenon, and then the latter must be forced into the mortise, the wedges thus becoming driven home by the pressure of their heads against the bottom of the mortise. This is called *fox wedging* or *foxtail wedging*.

When stub tenoned members are of minor character, coming between others, fox wedging is not necessary. In light work glue alone is relied on, and in heavy work the parts are held together by exterior attachments independently of the stub tenon joints.

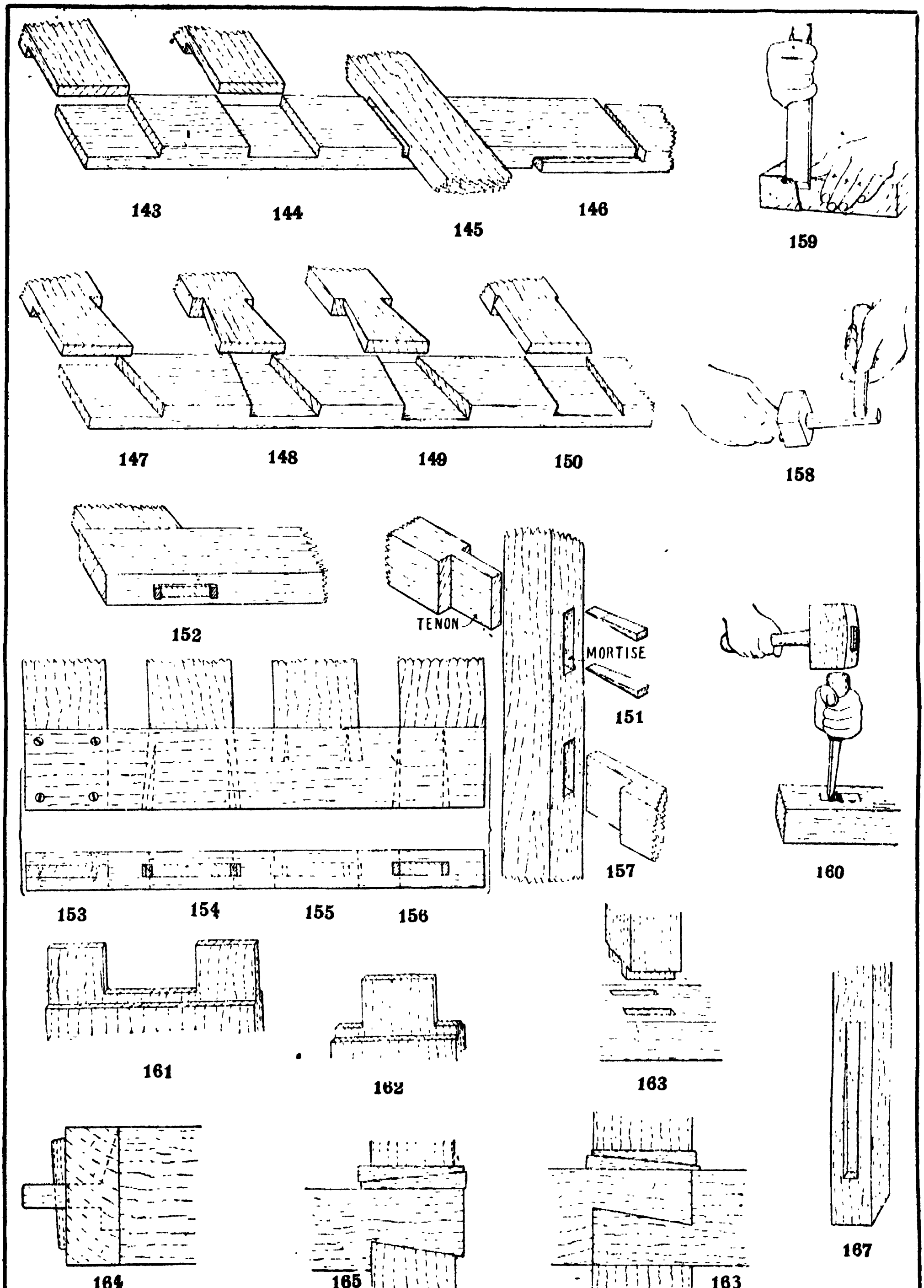
In putting a tenoned frame together, cramps are used to pull the joints up tightly, and these are left on for a time until the glue has set.

Drawboring. Drawboring with pins is done on the same principle as that in which a cottar draws two parts together. That is, the tapering side of the cottar acts as a wedge against the side of the hole in one of the parts, while it exerts pressure in the opposite direction in the other part. This is done by making the holes slightly out of centre with each other, so that when the pin is driven through, it exercises an inward pull on the tenon. The same principle is often put into practice in the insertion of screws into half-lap joints, and into any places where the piece of wood which is being screwed down has at the same time to fit closely against a shoulder or other part, which makes a side pull as well as a downward one desirable when screwing it down. The screw holes are bored through the first piece in the ordinary way, as described in our remarks about the insertion of screws, but in continuing the smaller hole on into the second piece the gimlet or bradawl is kept out of the centre relatively to the large hole, toward the side to which it is desired the screw shall pull the upper piece of wood. When the screw is put in it tends to bring the holes concentric with each other, and so exercises a side pull on the wood. The pins for drawboring tenoned joints are generally made by paring them with a chisel against the bench hook or stop, first making them square with a slight amount of taper in their length, and then removing the corners to make them octagonal.

Marking Out and Cutting Mortises and Tenons. Tenoned joints are so commonly employed, and they have such special features of their own, that there are several tools which are used almost exclusively in making them. One of these is the *mortise gauge*. An ordinary gauge might be used for marking out mortises and tenons, but it would involve two operations, where one with the mortise gauge suffices. The latter has two nickers instead of one, and marks two lines representing the width of the mortise. This width, of course, can be adjusted to whatever is required, and the block of the gauge can be set in the same way as that of a single marking gauge to fix the distance of the lines from the edge of the wood. Another important tool, little used except for mortises, is the mortise chisel. It is an exceptionally stout chisel, suitable for withstanding the heavy malleting and prising necessary in cutting and clearing out mortise slots.

The mortise gauge and an ordinary square are the tools used in marking out mortises and tenons. It is essential that the wood should first be planed square and true before either square or gauge can be used with accuracy. In marking out tenons, the entire length of the wood from shoulder to shoulder is usually the important thing to look after, and generally, if the tenon goes through, some allowance is left on its end for trimming off after the work is put together [152]. The extreme ends of the wood, therefore, do not need squaring, but care must be taken to scribe the shoulder lines square. The lines for these are squared completely round the wood. Then the lines of the tenon are gauged with the mortise gauge, which is used also without alteration for the mortise lines. It is generally set direct from the chisel that is to be used to cut the mortise slot [158]. If the mortise is to go right through, it is marked out on both sides of the wood, and allowance made on the outer side for the wedges [151 and 152]. If it be for a stub tenon, it is marked on the one face, and greater care taken to cut it square from that face, undercutting the correct amount for wedges if wedges are to be inserted. When mortises are cut near the ends of wood, as at the tops and bottoms of doors, a little extra length is left on the ends for sawing off after the work is together [152]. This gives more strength for wedging, and is simpler and better than squaring the pieces exactly to length before putting together. The tenon is sawn nearly to the lines, and finished with a chisel, or in large tenons it may be sawn practically to a fit, and eased, if necessary, with a rebate plane. To facilitate insertion, the sharp corners at the ends of tenons are chamfered off with a chisel, but in the case of through tenons, the chamfered part must be trimmed off after. Usually, most of the mortise slot is first cleared out by boring a series of holes with a centre-bit, and then it is cut to the lines with a mortise chisel, which, except in cutting small amounts at the finish, is driven by a mallet [160]. The mortise chisel used should always be of the same width as the mortise, and if care be taken to hold it upright, this ensures the sides of the mortise being parallel, and of the correct width. Mortises for stub tenons should be cut slightly deeper than the length of the tenon, to ensure a close bearing at the shoulder. Wedges are sawn of the same thickness as their tenons, and glued and driven in, either at the sides [152] or into the saw cuts [154 and 155]. Stub or stump tenons [155] are used when the tenoned member has merely to withstand side thrust, and is not required to have a strong tensile hold on the mortised member. It has the further advantage of weakening the mortised member less than would be the case if a through mortise were cut; and also, being concealed, it is sometimes preferred for the sake of appearance. In some cases also, the width of the mortised member is so great that there would be no gain in strength if a tenon was carried through.

Proportions of Tenons. In ordinary framed work, mortises and tenons are usually made one-third the thickness of the stuff, and unless the width of the tenoned member is more than about six times the thickness of the tenon, the latter is made the full width of the former; except, of course, in mortises cut at ends, where the width must be reduced to leave material beyond [152 and 156]. If the tenoned



TIMBER JOINTS

143. Half-lap joint at the end of two pieces meeting at right angles 144. Half-lap at an intermediate position 145. Half-lap in which the pieces cross 146. Half-lap between ends of timbers in line 147. Half-lap notched on one side to form half dovetail 148. Dovetailed halved joint 149. Dovetailed half-lap, with bevelled face 150. Veed edges 151. Mortise and tenon joint apart 152. Mortise and tenon together 153. Open mortise and tenon 154. Mortise and tenon safe wedged 155. Stub tenon fox wedged 156. Tenon reduced in width to avoid cutting through 157. Barefaced tenon 158. Setting a mortise gauge 159. Paring an end 160. Cutting a mortise 161. Pair of tenons 162. Haunched tenon 163. Double tenons 164 Tusk tenon 165 and 166. Dovetail tenons 167. Chase mortise

piece exceeds this proportion of width, the tenon is reduced, generally with a haunch, of which we shall speak immediately; or if the piece be very wide, more than one tenon is cut on its end. Fig. **161** shows what are called a *pair of tenons* cut on a wide piece. This is usually done in the middle and bottom rails of ordinary house doors. If a single tenon the full width were made, it would necessitate a mortise so large that the mortised member would be weakened very much, and there would be a risk of so wide a tenon becoming loose through shrinkage. In thick stuff, tenons are sometimes divided in the direction of the thickness, forming two thin tenons side by side, with a space between instead of one thicker one. These are called *double tenons* [**163**]. Mortises and tenons must always be arranged so that the long way of the mortise runs with the grain of the wood. Tenons are always formed on end grain, and mortises in side grain.

Haunching. When tenons do not extend the entire width of the member they are cut on, a short *haunch, stump,* or *tusk* [**161** and **162**] is often formed extending the full width of the member, and of the same thickness as the tenon. A shallow mortise is cut to receive the haunch, and when in place the tenoned member is thus prevented from warping as effectually as if the tenon itself was of full width. In fact, the haunch makes it equivalent to a tongued and grooved joint, and the tenon may be considered as an extension of the tongue. Haunched tenons are always employed in panelled doors, the haunches fitting in the same grooves as the panels, and extending the same distance in as the latter.

Tusk Tenon. A tenoned joint somewhat similar in principle is shown in **164**. It is called a *tusk tenon,* and in this case the prevention of the member from warping is, of course, not the idea, because it is not of a section that could warp. It is the joint generally used in fitting the ends of floor joists into framing where openings have to be left for fireplaces, stairs, etc., but it is suitable for any cases where the end of one horizontal timber has to be tenoned into another. The tenon which goes through and is kept in place by a pin or wedge on the far side is of comparatively small section in order to avoid weakening the timber in which the mortise is cut, but, to enable the joist to support as heavy a weight as possible, a short tusk is made which relieves the slender tenon from a great deal of shearing stress and yet weakens the mortised timber very little. Sometimes, when the latter is very wide, the tenon does not go through, but the pin which holds it in place is driven down through a hole bored from the top. The proportions adopted for a tusk tenon are shown to scale in **164**, and it is always intended of course to be used in the position shown, with the square shoulder downward and the bevelled part at the top. The haunches of tenons like **152** and **162** are sometimes tapered similarly so that they may not show when the parts are together.

Dovetail Mortise and Tenon. This is shown in **165** and **166**. It is used chiefly for temporary work. As the illustration shows, it is inserted loosely, and tightened by wedges. Fig. **165** shows the end of a single rail inserted in this way, and **166** shows two rails meeting in a post. It can also, if necessary, be used for stub tenons.

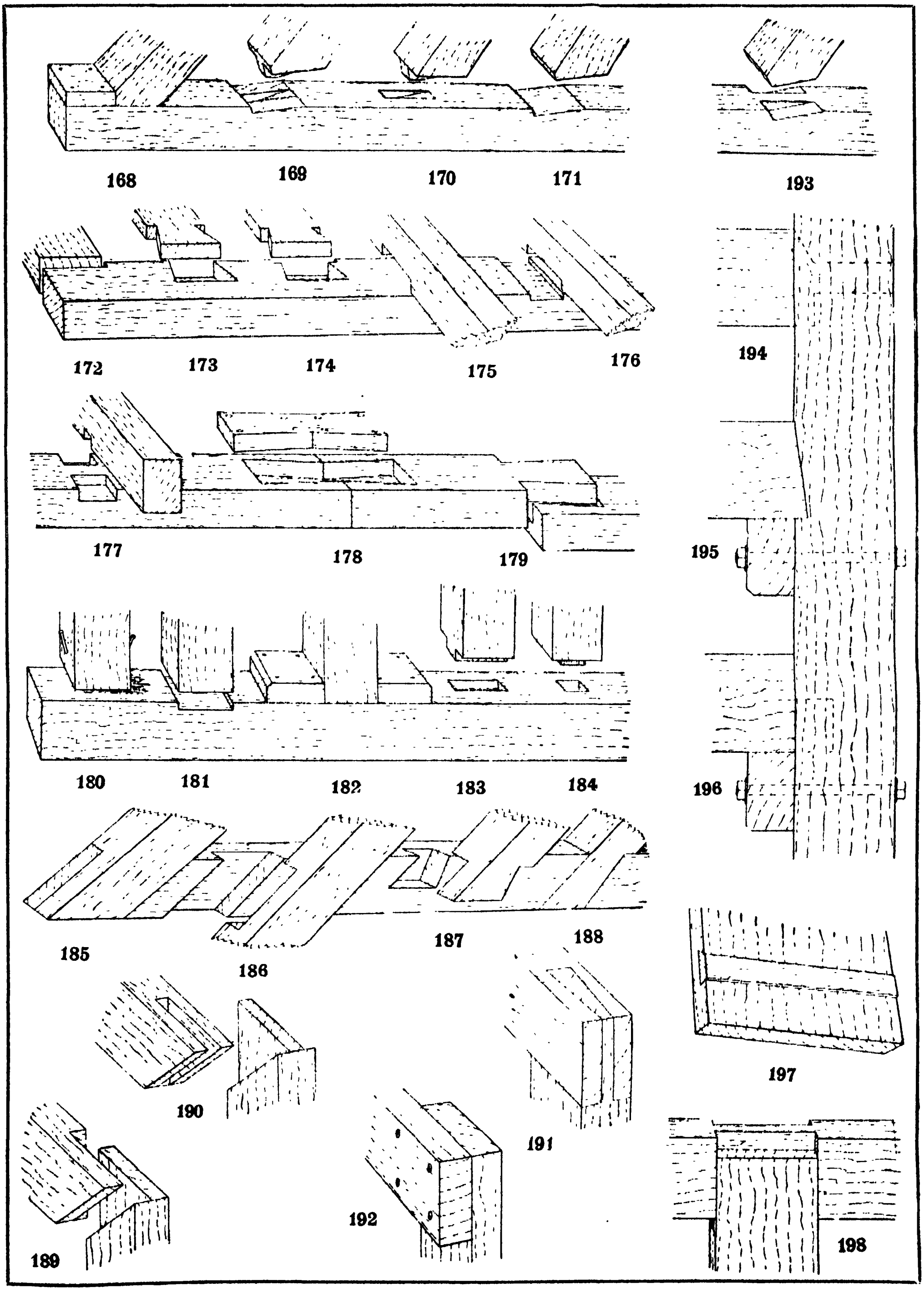
Open Mortise and Tenon, or Slot Mortise. This [**153**] is a slight improvement on a halved joint, and it permits of a wider, and consequently stronger, tenon than could be employed if it were enclosed in the ordinary way. Such a joint can be held together only by pins or screws, in the same way as a halved joint.

Barefaced Mortise and Tenon. This [**157**] is employed when the members are of unequal thickness, but are flush with each other on one face. The tenon is then shouldered back from the flush face only, and on the other face of the thin member the tenon is continuous with the surface.

Chase Mortise. The chase mortise [**167**] is employed in cases where a tenoned member has to be inserted after a frame has been put together, and as it is impossible to insert the tenoned ends endwise in the usual way, one of the mortises is cut away at the side for some distance, and the tenoned member inserted in the frame diagonally, with one tenon at the entrance of the ordinary mortise and the other at the end of the chase mortise. It can then be pushed sideways along the chase mortise until both tenons are in their proper place. The chase mortise is then generally filled up by inserting a strip of wood.

Oblique Mortise and Tenon. Examples of this are shown in **169** and **170**. Other slight modifications of their form are possible, and sometimes employed. In **169** the end of the member itself is recessed a little way into the mortised timber, the tenon extending further still. In **170** the tenon only enters the surface of the mortised member. In another form frequently employed, the tenon is shouldered or notched back slightly from the front, and sometimes also, instead of tapering to nothing at the back, some amount of depth is given to it there. Occasionally the tenon is notched, giving it the appearance of two saw teeth, one behind the other. Sometimes a joint the exact reverse of a mortise and tenon, known as a *bridle joint* [**193**], is made. It has no particular advantage of its own, except that it is then possible to see from the outside whether it is in close contact everywhere. Figs. **168** and **171** show two simpler forms of joint which might be used under the same circumstances. In **168** a block is nailed on the surface of one member to take the thrust of the other. In **171** the member is notched out to provide a shoulder for taking the thrust.

Miscellaneous Joints. There are a number of joints commonly employed, some of which are closely allied to the tenoned joint or to the simpler forms already described. Figs. **172** to **177** show methods of connecting timbers which meet, or cross at right angles. Fig. **172** is a rebated joint which is employed to resist pressure inwards on either member; **173** is a dovetailed joint to resist tension; **174** is a similar joint, except that its end is housed to enable it to withstand



TIMBER JOINTS

168. Oblique butt joint in which thrust is taken by a block 169. End of member recessed and stub-tenoned into the surface 170. Stub-tenoned only 171. Recessed only 172. Rebated joint 173. Dovetailed joint 174. Dovetailed and housed joint 175. Notched joint 176. Double notched joint 177. Cogged joint 178. Dovetail key uniting pieces end to end 179. Dovetail formed on the end of one piece 180. Skew-nailed butt joint 181. Rebated or housed joint 182. Stepped joint 183. Stub tenon 184. Joggle 185. Halved oblique joint between two ends 186. Halved joint between pieces crossing obliquely 187. Halved dovetail joint not going completely through 188. Similar dovetail which does go through 189. Half-lap, mitred on one face and square on the other 190. Open mortise and tenon with mitred shoulders 191. Open mortise and tenon dovetailed 192. Plain lap 193. Bridle joint 194. Housed and tenoned joint 195. Notched joint with cleat 196. Stub-tenoned joint with cleat 197. Dovetailed key 198. Forked tenon

downward pressure ; **175** is a notched joint to prevent the notched timber from moving endwise ; and **176** shows a double notched joint to prevent either timber from moving endwise. If the timbers were sunk flush with each other, it would be a halved joint. Fig. **177** is a cogged joint used for preventing end movement between timbers which cross. The lower one is thus not weakened so much as it would be if notched entirely through, while another advantage is that, even if the end of the upper one be flush with the outer face of the lower, there is still some amount of end grain to prevent the upper from moving back. Fig. **178** illustrates a separate dovetailed key uniting timbers end to end ; **179** is an end joint in which the key is formed on the end of one of the timbers ; **180** to **184** show joints adopted for connecting verticals with horizontals, the horizontals being either above or below ; **180** is a simple butt joint, skew-nailed, or in large joints, spiked, not possessing, of course, very much strength except to resist direct downward pressure ; and **181** has its end let into a shallow recess or rebate, and would be called a *housed joint*, though, strictly speaking, a housed joint is one in which the end of the member is enclosed on all sides. In **182** the vertical is held in practically the same way, the only difference being that, instead of a recess being cut in the horizontal, two blocks or steps are nailed on each side to enclose the end of the vertical. Fig. **183** is a simple stub tenon, and **184** a joggle. Another good method for a wide post would be double tenons as in **136**.

Some More Complicated Joints. In addition to these, there are other more complicated joints, mostly without any corresponding advantage, which might be employed. Figs. **185** to **188** are oblique halved joints, which otherwise do not differ from forms already described. Fig. **189** is a corner joint which is simply a half-lap mitred on one face and square on the other, the mitre being made for neat appearance, and at considerable sacrifice of strength. Fig. **190** is an open mortise and tenon with mitred shoulders ; not so strong as square shoulders, but even with its double mitre rather stronger than **189** ; **191** is a dovetail, a very substantial joint, superior to a mortise and tenon for resisting tension. In **191** the dovetail is formed to resist outward pressure on the vertical member, but it could, if necessary, be tapered the other way to prevent the horizontal from being forced upwards. Fig. **192** is a plain lap joint, which would have to be screwed or bolted together ; **197** shows a tapered and V-edged key fitted in a corresponding groove across a wide piece of wood to strengthen and prevent the latter from curving or warping. It may be planed flush with the surface, or allowed to stand a little above it, as in the illustration, the advantage of the latter method being that it is thicker, and therefore less likely to get bent itself by the large piece. On the other hand, the flush surfaces are neater, and sometimes essential. When there is no objection to a thick key standing above the surface, it is often a question whether a simple batten screwed on instead would be preferable.

Heavy Timber Joints. Figs. **194** to **196** show some methods of connecting beams with posts in heavy timbering ; **194** very much resembles the tusk tenon in **164**, but it is stronger than the latter, because the entire depth of the horizontal is housed, which in **164** is impossible. The entire depth and width of the horizontal is supported in the housing, and therefore could not shear off, except under a weight that the beam itself was too small in section to sustain. Housing is often practised in jointing horizontal members when they happen to be of smaller section than the members that support them. Fig. **195** is another example which, although it is open at the sides, has its entire section supported. In this case, a shallow notch is cut in the vertical, and the support increased by bolting a cleat beneath. The notch may be either parallel in the form of a rebate, or tapering to nothing at the top, the latter method not weakening the post quite so much, but the difference is hardly worth considering.

In **196** the end of the beam is tenoned into the post and supported also by a cleat. A stub tenon formed on the lower half of the end is used so that the beam is supported from the bottom. The cleat in both cases is shown bolted to the surface, but it might be made more secure by notching it in the same way as the end of the beam in **195**. Fig. **198** is called a *forked tenon*, but it is practically the same thing as the open mortise and tenon [**153** and **190**], except that it occurs at an intermediate position instead of at an end. It is sometimes used in framed work when the forked end has to support the other in a horizontal position, as in the illustration. It holds it more securely than if it was tenoned into it in the ordinary way ; but, on the other hand, the horizontal is very much weakened by cutting so much material from its body. The edges of this joint are generally slightly veed or undercut in order to keep the main surfaces of the joint in close contact.

Continued

continued from page 3915

PERMUTATIONS AND COMBINATIONS

**Number of Ways of Arranging Things when Some are Alike.
The Binomial Theorem. Proof for a Positive Integral Index**

By HERBERT J. ALLPORT, M.A.

PERMUTATIONS

161. The number of *arrangements* of r things which can be formed from n things is called the number of *permutations* of n things r at a time. This number is denoted by ${}^nP_r$.

For example, if we have three letters, a, b, c, the number of permutations which can be formed by choosing the letters two at a time is six. The permutations are

ab, ac, bc, ba, ca, cb.

162. To Find ${}^nP_r$. Since there are n different things, one thing can be chosen in n ways. Having chosen one thing, there will be $(n-1)$ things left, so that a second can be chosen in $(n-1)$ ways. Now, when a second thing is chosen, it can be placed with any one of the n ways of choosing the first; hence, from *each* way of choosing the second thing we get n ways of choosing *two* things. Therefore, since there are $(n-1)$ ways of choosing the second, we get $n\ (n-1)$ ways of choosing two things.

Again, when two things have been chosen in any one of these ways, a third thing can be chosen in $(n-2)$ ways; thus, since two things can be chosen in $n\ (n-1)$ ways, and a third in $(n-2)$ ways, the number of ways of choosing three things is $n\ (n-1)\ (n-2)$.

Proceeding in this manner, we see that the number of ways of choosing r things is

$$n\ (n-1)\ (n-2) \ldots \text{to } r \text{ factors.}$$

Now the rth factor is evidently $n-(r-1)$, or $n-r+1$. Hence we get

$${}^nP_r = n\ (n-1)\ (n-2) \ldots (n-r+1).$$

163. If we put $r=n$ in the result of Article **162**, we obtain the number of ways of arranging n different things amongst themselves.

Thus $\quad {}^nP_n = n\ (n-1)\ (n-2) \ldots 3\,.\,2\,.\,1\,.$

This expression, consisting of the product of the first n natural numbers, is denoted by the symbol $|\underline{n}$ or $n\,!$ and is called "factorial n."

164. *To find the number of permutations of n things taken all together, when the things are not all different.*

Suppose the n things are letters, p of them being a's, q of them b's, r of them c's, and the rest all different. Let x be the required number of permutations. Now each permutation contains the whole of the n letters, so that each contains p letter a's. Suppose that instead of these a's we put in p letters which are different from one another and from all the rest. Then, by arranging these p letters we get $|\underline{p}$ permutations [Art. **163**] instead of a single permutation. Treating each of the x permutations in the same way, we should obtain $x \times |\underline{p}$ permutations.

Again, each of these $x \times |\underline{p}$ permutations contains q letter b's, and, exactly as before, if we change these q letters into letters which are different from one another and from all the rest, we should obtain $|\underline{q}$ permutations from each of the $x \times |\underline{p}$ permutations. Hence the number of permutations will now be $x \times |\underline{p} \times |\underline{q}$.

Similarly, by changing the r letter c's, we get

$$x \times |\underline{p} \times |\underline{q} \times |\underline{r} \text{ permutations.}$$

But the n letters are now all different, and, therefore, the number of ways of arranging them is $|\underline{n}$ [Art. **163**].

$$\therefore\ x \times |\underline{p} \times |\underline{q} \times |\underline{r} = |\underline{n},$$

and
$$x = \frac{|\underline{n}}{|\underline{p}\ |\underline{q}\ |\underline{r}}.$$

COMBINATIONS

165. The number of *groups* of r things which can be chosen from n things, without regard to the *arrangement* of the r things in each group, is called the number of *combinations* of n things r at a time. This number is denoted by ${}^nC_r$.

166. To Find ${}^nC_r$. Each combination contains r different things, and, by Art. **163**, these r things can be arranged in $|\underline{r}$ ways. Hence, each combination gives rise to $|\underline{r}$ permutations, so that

$$|\underline{r} \times {}^nC_r = {}^nP_r.$$

Therefore,

$${}^nC_r = \frac{{}^nP_r}{|\underline{r}} = \frac{n\ (n-1)\ (n-2) \ldots (n-r+1)}{|\underline{r}}.$$

By multiplying numerator and denominator of the expression on the right by $|\underline{n-r}$ we get another form of the result, *viz.*,

$${}^nC_r = \frac{n\ (n-1)\ (n-2) \ldots (n-r+1)\ |\underline{n-r}}{|\underline{r}\ |\underline{n-r}} = \frac{|\underline{n}}{|\underline{r}\ |\underline{n-r}}.$$

167. *The number of combinations of n things taken r at a time is equal to the number of combinations of n things taken $(n-r)$ at a time.*

For, in taking r things away from n, we leave $(n-r)$ things behind. Hence the number of ways of choosing $(n-r)$ things is the same as the number of ways of choosing r things; that is $\quad {}^nC_r = {}^nC_{n-r}$.

EXAMPLES 35

1. How many different numbers can be formed by using one or more of the numbers 1, 2, 3, 4 ?

2. How many permutations can be formed by taking all the letters of the word *Philadelphia* ?

3. In how many ways can six people sit at a round table ?

4. In how many ways can three boys and two girls be chosen from six boys and three girls ?

5. If ${}^nC_7 = {}^nC_8$, find ${}^nC_3$.

6. Of the permutations formed by using all the letters of the word *successes*, how many have s at each end ?

THE BINOMIAL THEOREM

168. In Article **27** it was shown that the product of two compound expressions is obtained by taking the sum of the products formed by multiplying every term of the one expression by every term of the other. In the same way we obtain the continued product of any number of expressions by taking the sum of all the products formed by multiplying together any term of the first, any term of the second, etc.

Suppose we have n factors, each of which is $(a+b)$, and that we wish to form their product. If we take a letter from each factor and multiply these letters together we obtain a term of the product. By doing this in every possible way we obtain every term of the product.

We can take the letter a from each factor, and this can only be done in one way. Hence a^n is a term of the product. Again, b can be taken from one factor and a from the remaining $(n-1)$ factors; the number of ways in which one b can be chosen is the number of ways of choosing one thing out of n things, or ${}^nC_1$. Thus the product $a^{n-1}b$ can be formed in ${}^nC_1$ ways, so that ${}^nC_1a^{n-1}b$ is a term of the continued product. Similarly, b can be taken from 2 factors and a from the remaining $(n-2)$; the number of ways of choosing two b's is ${}^nC_2$, so that ${}^nC_2a^{n-2}b^2$ is a term of the continued product.

Proceeding in this way, we obtain

$$(a+b)^n = a^n + {}^nC_1a^{n-1}b + {}^nC_2a^{n-2}b^2 + \ldots + {}^nC_{n-1}ab^{n-1} + {}^nC_nb^n;$$

or, using the values of ${}^nC_1$, ${}^nC_2$, etc. [Art. **166**.],

$$(a+b)^n = a^n + na^{n-1}b + \frac{n(n-1)}{1\,.\,2}\,.\,a^{n-2}b^2 + \ldots + nab^{n-1} + b^n.$$

This formula is the *Binomial Theorem*, and the expression on the right is called the *expansion* of $(a+b)^n$.

Example. Expand $(2x-y)^4$.

By putting $a = 2x$, $b = -y$, $n = 4$, in the above formula, we obtain

$$(2x-y)^4 = (2x)^4 + 4\,(2x)^3\,(-y) + \frac{4\,.\,3}{1\,.\,2}\,(2x)^2\,(-y)^2 + 4\,(2x)\,(-y)^3 + (-y)^4$$
$$= 16x^4 - 32x^3y + 24x^2y^2 - 8xy^3 + y^4 \quad \underline{Ans.}$$

169. General Term. In the expansion of $(a+b)^n$ a term of the continued product is formed by taking b from r of the factors and a from the remaining $(n-r)$ factors. Now r b's can be chosen from n in ${}^nC_r$ ways, so that

${}^nC_ra^{n-r}b^r$ is a term of the expansion.

By giving a suitable value to r we obtain any term in the expansion; ${}^nC_ra^{n-r}b^r$ is therefore called the *general* term.

Note that in Art. **168** the index of b in the second term is 1, in the third term is 2, and so on; hence the term containing b^r is the $(r+1)$th term, not the rth.

Example. Find the 7th term of $(3a-1)^{11}$.

$$\text{7th term} = {}^{11}C_6\,(3a)^{11-6}\,(-1)^6$$
$$= \frac{11\,.\,10\,.\,9\,.\,8\,.\,7}{2\,.\,3\,.\,4\,.\,5}\,.\,3^5\,.\,a^5$$
$$= 112266a^5 \quad \underline{Ans.}$$

170. In the expansion of $(a+b)^n$ the coefficient of the $(r+1)$th term from the beginning is ${}^nC_r$.

The coefficient of the $(r+1)$th from the end, *i.e.*, the $\{(n+1)-r\}$ or $(n-r+1)$th from the beginning, is ${}^nC_{n-r}$.

But ${}^nC_r = {}^nC_{n-r}$ [Art. **167**], hence, *in the expansion of $(a+b)^n$ the coefficients of any two terms equidistant from the beginning and end are the same.*

171. The most useful form of the Binomial Theorem is obtained from the result of Article **168** by putting $a = 1$ and $b = x$. This gives

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{1\,.\,2}x^2 + \ldots + x^n.$$

Example.

$$(2x+3a)^5 = (2x)^5\left(1+\frac{3a}{2x}\right)^5$$
$$= 32x^5\left\{1 + 5\,.\,\frac{3a}{2x} + \frac{5\,.\,4}{1\,.\,2}\,.\,\frac{9a^2}{4x^2} + \text{etc.}\right\}$$
$$= 32x^5 + 240x^4a + \text{etc.}$$

172. The formula of Article **171** has only been proved for the case where n is a positive integer, but the result is true for *all* values of n, provided x is less than 1. We shall not give a proof of this, but an example will show the application of the formula to cases in which n is not a positive integer.

Notice that, if n is not a *positive* integer, no one of the factors n, $n-1$, $n-2$, etc., can be zero, so that the expansion is endless.

Example. Expand $(1+x)^{-\frac{1}{2}}$

The formula gives

$$(1+x)^{-\frac{1}{2}} = 1 + \left(-\frac{1}{2}\right)x + \frac{\left(-\frac{1}{2}\right)\left(-\frac{1}{2}-1\right)}{1\,.\,2}x^2 + \frac{\left(-\frac{1}{2}\right)\left(-\frac{1}{2}-1\right)\left(-\frac{1}{2}-2\right)}{1\,.\,2\,.\,3}x^3 + \ldots$$
$$= 1 - \frac{1}{2}x + \frac{1\,.\,3}{2\,.\,4}x^2 - \frac{1\,.\,3\,.\,5}{2\,.\,4\,.\,6}x^3 + \ldots \quad \underline{Ans.}$$

Answers to Algebra

Examples 34

1. 86.
2. 5, 8, 11, 14.
3. 512.
4. (i.) 360, (ii.) 25, (iii.) $4\frac{1}{8}$, (iv.) $\frac{3+\sqrt{3}}{2}$.

Examples 35

1. ${}^4P_1 + {}^4P_2 + {}^4P_3 + {}^4P_4 = 4 + 12 + 24 + 24 = 64$.

2. $\dfrac{|12}{(|2)^5} = 14968800$.

3. $|5 = 120$.

4. ${}^6C_3 \times {}^3C_2 = 20 \times 3 = 60$.

5. ${}^nC_7 = {}^nC_8 = {}^nC_{n-8}$ [Art. **167**]. Therefore, $n - 8 = 7$, and $n = 15$. Hence, ${}^nC_3 = 455$.

6. Taking away two s's first, we can arrange the remaining letters in $\dfrac{|7}{|2\;|2\;|2}$, or 630 ways. The letters taken away can be put one at each end of any arrangement. Hence the required number is 630.

Algebra concluded

SUGAR
continued from page 3831

SUGAR-BEET GROWING

Propagation, Selection, and Characteristics of Beetroots. Sowing, Hoeing, and Harvesting. Manures. Beet-growing in the United Kingdom

SUGAR beet is grown in all the countries of Europe from Sweden in the north to Spain, Italy, and Greece in the south. It is cultivated in Canada and the United States, Australia, South Africa, Persia, and Siberia. The plant (*Beta vulgaris*) is indigenous to the South of Europe.

Propagation. Beet is propagated from seed. The original beet has been improved by a careful selection of the best sugar bearers, and judicious and scientific fertilising have evolved beets which contain as much as 18 per cent. of sugar. Vilmorin, of Paris, was the pioneer in this work of selection, and his successors, Vilmorin, Andrieux & Co., are still recognised as the premier house for beet seed. In England the houses of Sutton and Carter have paid considerable attention to the production of a good sugar-bearing beet, and both sell a good seed suitable for growing in England.

Selection. The method of selection is as follows: The beetroots which show least root above ground are pulled and stored, and in the spring those richest in sugar are planted out for seed. Richness in sugar is found by putting the roots into a solution of salt or sugar of the specific gravity of 1·065 to 1·070. Roots rich in sugar sink, and these are selected for planting, those floating being rejected. This test is a rough one, but answers well, a more scientific method being to test small quantities of the juice by the *polariscope*. The beets selected are placed in the ground and long seed stalks spring from them. The stalks are supported by sticks, and when the seeds are nearly ripe the stalks are cut and the ripening finished by hanging in sheds in a current of air. The yield of seed is about 15 cwt. per acre. Beet giving a large sugar yield costs no more to grow than beet with a small yield, so that the selection of seed is an important matter to the grower. Illustrations are given of the Vilmorin Improved, the White Silesian, from which the former is descended and sometimes regarded as a distinct species, and the Imperial [9]. Other well-known kinds are the Klein-Wanzleben, and Heine's Vilmorin [see Plate facing page 3649].

Characteristics of Good Beet. The shape and manner of growing of the beet are important. The most desired characteristics are thus summed up by Lock:

1. Beets should have a regular pear-shaped form and smooth skin.

2. They should not have a tendency to throw out forks or fingers and toes.

3. The flesh should be firm and white, the structure uniform, and the flavour "clean." Thin-skinned beets are preferable, as the thick-skinned varieties are frequently spongy and always more watery.

4. The beets should weigh 1½ lb. to 2½ lb. each, as neither very large nor very small roots are profitable to the manufacturer.

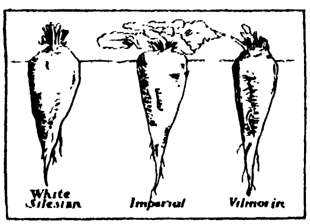
5. Good beets have no tendency to become necky, and their tops are always smaller than those of inferior beets. The large-leaved are preferable to the small-leaved varieties.

6. Good beets are denser than water. The quantity of sugar is roughly estimated as stated above. If the beets sink in a liquid of 1·07 sp. gr. the percentage of sugar is about 14.

7. The roots should grow entirely in the ground in properly prepared soil.

Range of Temperature. Authorities are agreed that temperature has to be considered in beet cultivation rather than the rainfall. Sugar formation is favourably influenced by dry weather in the autumn. A mean summer temperature of 70° F. for 90 days is sufficient to mature beetroot; if the temperature be much above this the amount of sugar is diminished. The crop must be matured and safely harvested before the frosts set in.

Soil. Any good soil that will grow wheat and has an arable depth of 12 in. to 15 in. is well suited for beet culture; it must be well drained. Where a large proportion of chalk is present in the soil the juice yield of the beet is small but of good quality. In the United States, Dr. H. C. Meyers devoted much time to the study of the growth of beet in alkaline soil such as exists in Utah. The locality in which the experiments were made was at Hooper, slightly above the mud flats of Great Salt Lake. Dr. Meyers found that moderate irrigation tends to carry the salts in the soil down to below the plant roots, and that by deep tillage, maintained throughout the season, evaporation and rising of the alkali may be largely prevented. Alkali soils have a great advantage over other soils in case of drought, in that the hygroscopic salts present take up and retain moisture which is available for plants. The tendency of the beet is to purify the soil by taking up alkali constituents ruinous to common crops. The importance of these observations is that arid regions unsuitable for any other crop may be utilised for beet.



9. SUGAR BEETS

Sowing. In Great Britain April is the time for sowing beet seed. The frosts should be over, because if the sowing be done too early

and the plants become frost-bitten it will be necessary to plough up the first sowing and sow afresh. Some sow the seeds in continuous lines along ridges which have been thrown up from 14 in. to 18 in. apart. The ground should have been stirred up to a depth of 12 in. by the cultivator or subsoil plough, and if manured, the manure is ploughed in 5 in. deep. A better way than the continuous line is to dibble the seeds, three in each hole. To keep the beets down to the limits of size—½ lb. to 2½ lb.—they are planted with about 8 in. between the roots, bearing in mind that some of the new kinds of beet with strong foliage require the rows to be up to 20 in. apart instead of the 18 in. limit just referred to. The seedlings are allowed to grow until 3 in. to 4 in. high, and where more than one plant has come up from each hole, the weakest are pulled up, and any misses filled up with these plants. The quantity of seed required, if sown in continuous line, is 10 lb. to 15 lb. an acre; if dibbled in, 5 lb. to 7 lb.

Hoeing. As soon as the plants appear above the ground the soil should be kept loose and free from weeds by hand hoeing. After thinning and until the plants have grown too large, the horse hoe may be used two or three times, its work being finished off each time with a hand hoe. The soil should be earthed up so as to cover the roots. If any plants begin to send up stalks, the stalks should be at once broken off.

Harvesting. The crop must not be harvested until it is ripe, but at the same time it should not be left to be injured by the frost. In from three to seven months the leaves begin to droop and turn yellow, leaving exposed on the top of the root a crown of young green sprouts. As soon as this takes place, the roots are ready to be pulled. If the autumn be cold and dry, the roots may be left without injury for a week or ten days later, but if the weather be mild and moist, new growth would be encouraged, which is undesirable. The roots are pulled by hand labour, but more economically by special harvesters, consisting of a fork on wheels, drawn by horse power. The roots are caught by the prongs of the fork, which pulls them out of the ground and drops them. Care is taken not to puncture or bruise the roots, as this means loss of sugar. The earth is shaken off the roots, the leaves and crown cut off, and the beets carted to the factory. If the roots are to be stored in silos, only the leaves are removed, and they are stored as soon as possible in well-ventilated underground trenches covered with soil, or in properly constructed silos [see AGRICULTURE, page 1970], the object in storing being protection from the consequences of overheating, frost, and too rapid sprouting.

Use of Manures. The use of manure depends on the nature of the soil. It is generally recommended not to manure the beet crop directly, but to heavily manure a preceding cereal crop, and let the residue of manure serve for the beet. With modern artificial manures, however, the amount of manure can be adjusted to actual requirements, making it advantageous to manure the crop directly instead of indirectly. Nitrogenous compounds have a tendency to extend the period of growth and delay the time of ripening. This tendency must be corrected by phosphates. The Victorian Department of Agriculture recommend for light dressing 2 cwt. of sulphate of ammonia and ⅘ cwt. of superphosphate, and for heavy dressing 4 cwt. of sulphate of ammonia and 1⅗ cwt. of superphosphate per acre. Where potash is needed, ⅝ cwt. to 1¼ cwt. of kainite may be used.

Sugar Factory Refuse as Manure. The cost is heaviest the first year, because subsequently the refuse of the sugar factory is returned to the land, and goes a good way in keeping the soil manured. Stable manures must be used either on the preceding cereal crop, or worked into the soil in the autumn ploughing. Chili saltpetre or nitrate of soda can be used in place of sulphate of ammonia, and the calcium nitrate produced electrolytically in Norway is equally efficient. The United States Government have carried out a large number of experiments on the effect of manures on beet crops. The fertiliser was found to increase the yield of beets but not the percentage or the purity of sugar. The use of 500 lb. of fertiliser per acre decreased the cost of the beets 11d. per ton; the application of larger quantities did not produce any further decrease in the cost of beets, so that 500 lb. is the most economical quantity to use. When 20 tons of stable manure per acre were applied instead of artificial fertiliser, an increase of yield was found in every case as compared with unmanured plots, the average increase being 8,720 lb. per acre. The percentage of sugar was increased by an average of 1·5. In growing beets at different distances apart in the rows, it was found that the nearer the beets were to each other the smaller was the yield per acre, and the size of the roots was also less.

Diseases. Beet is sometimes attacked by grubs of the beet canon-beetle (*Sulpha opaca*), the beet or mangold fly (*Anthomyia betæ*), and the silver moth (*Plusia gamma*). These are overcome by spraying the upper and under sides of the leaves with Paris green solution. A disease known as "jaundice" is prevalent in the northern parts of France, and generally makes its appearance during the first fortnight in July. When the plant is first attacked the leaves begin to droop and become mottled with white translucent spots. It has been found that this is due to bacteria, and as the sugar yield is reduced by a half in diseased roots, the refuse from the crop should be burnt before being returned to the land. When stored in silos, a slight loss of sugar takes place, and "greying" of sugar has been traced to dry-rot which sometimes sets in during storage.

Yield of Beet. An acre of roots weighing 2 lb. each, and growing 10 in. apart in rows 15 in. apart, would, if there were no misses, yield 40½ tons of dressed roots. The heaviest yield has been 65 tons, but 25 to 35 tons may be reckoned as the average. At 15s. a ton, this would yield from £18 15s. to £26 5s. per acre, the estimated cost being about £8 per acre,

leaving a direct profit of £10 to £18 per acre. This question has been dealt with by Mr. Sigmund Stein, who is a persistent advocate of beet-growing in England. His figures come out at £7 15s. 5d., made up as follows

	Per acre. £	s.	d.
Rent and taxes ..	1	0	0
Cleaning and forking weed stubble	0	1	0
Ten loads farmyard manure and carting	1	11	0
Spreading manure	0	1	0
Ploughing 8 in. to 10 in. deep	0	8	0
Carried forward	3	1	0

	Per acre. £	s.	d.
Brought forward	3	1	0
Cultivating	0	6	0
Artificial manure ..	1	10	0
Seed	0	6	8
Sowing	0	2	6
Drilling, hoeing, and thinning ..	0	11	0
Harvesting	0	10	0
Carting	1	8	3
	£7	15	5

Mr. Stein, reckoning on a minimum crop of 15 tons per acre, obtained on the balance-sheet a profit of £7 4s. 7d., as follows :

Dr.	£	s.	d.
Cost per acre to cultivate	7	15	5
Extra carting to the factory	1	10	0
Profit per acre ..	7	4	7
	£16	10	0

Cr.	£	s.	d.
15 tons beet at 18s. per ton	13	10	0
Value of 5 tons leaves and heads from roots	1	5	0
3 tons spent slices at 10s.	1	10	0
Value of saturation lime (free from factory)	0	5	0
	£16	10	0

Yield of Sugar. The mean sugar content of 1,200 samples of beet analysed by Graftian, a Belgian chemist, in 1898, was 16·4 per cent., the extremes being 20·2 and 12·5 per cent. About half the sugar is obtained as *first* sugars, the rest being divided between *second* sugars, *third* sugars, molasses, and losses. The average percentage of water in the beetroot is 77·69, and in the juice extracted 81·51, the average specific gravity of the juice being 1·077.

In 1879, a Select Committee of the House of Commons was appointed to inquire into the effect produced upon the home and colonial sugar industries of Great Britain by the bounty system in those countries which manufacture sugar for export. One of the witnesses, Mr. James Duncan, stated that Great Britain was adapted for beet cultivation, but that the bounty system of foreign countries, averaging £2 a ton, acted as a preventive of successful production of beet sugar in the British Isles. Dr. Voelcker, chemist to the Royal Agricultural Society, stated that he found 12 per cent. of sugar in roots grown in Suffolk ; 12·5 to 13 per cent. in roots from Berkshire ; 11·75 in roots from Surrey ; 10·5 to 13·25 in roots from Yorkshire, and 10, 12, and 13, up to 15 per cent. in roots from Killarney. Mr. Martineau had roots grown in Lincolnshire and the Isle of Thanet, and obtained 15 per cent. of sugar, compared with the average (at that time) of 10·5 per cent. in France.

Experiments in Great Britain. The factory which Mr. Duncan started was at Lavenham, but the venture was not a success. The quality of the beets improved year by year, but the farmers did not properly modify their rotations to secure a sufficient supply of beets for working at a profit. Sir J. B. Lawes and Sir J. H. Gilbert published, in 1898, a valuable summary on the conclusions they had arrived at as to the growth and manufacture of sugar in the United Kingdom. On the whole, the authors were rather sceptical as to the suitability of England as a beet-growing country, and although satisfactory crops could be obtained in certain districts, the results on the whole country, and on an average of seasons, were not, they said, likely to be profitable.

England too Cold. The perfected beetroot grown abroad is supposed to require an average temperature of 70° F., while statistics show that the mean temperature for July, the hottest month in the year is, in England, only 62·5° F., and for September and October, 50° F. and 43·2° F. respectively. These latter are the critical months during which the beet matures and ripens, and in England, October is nearly always rainy, and often frosty. Nevertheless, in favourable districts, it is probable that in the majority of seasons, a fair quality of beet for the manufacture of sugar could be grown if proper care were taken to gather the harvest before the early frosts appeared. These investigators strongly recommended the planting of the roots close together whereby the luxuriance of the foliage is limited, the purity of the juice increased and earlier ripening secured. Norfolk or Suffolk they considered most suitable for beet cultivation, the climate being appropriate, and the soil neither too light nor too heavy. They added that even if the Continental sugar bounties were reduced or abolished, beet growing could never be commercially profitable for the agricultural districts of Great Britain as a whole.

Why England should Grow Beet. Mr. Sigmund Stein, of Liverpool, has for years advocated beet-growing in England, and in December, 1905, he discussed the subject in a paper read before the Society of Arts. He enumerated the advantages which Great Britain possesses over Continental competitors. (1) We can grow more roots per acre ; (2) we can grow richer roots than on the Continent (3) we have the consumption at hand, since we are the greatest sugar consumers in the world ; (4) we save freight ; (5) we save commission, as the factory sells direct to the consumer ; (6) we can make use of the latest improvements in cultivation and manufacture by having at our disposal the best implements and machinery ; (7) we can manufacture refined sugar direct at a very low price ; (8) we can employ the plant of our works in the summer months after the campaign is over much better than the factories can do on the Continent, as we have many other industries in this country which could be well carried out in this factory.

The growing of beetroot is to be this year (1906) introduced in Essex for the manufacture of sugar on the spot, the Ipswich Chamber of Agriculture taking a great interest in the experiment.

Continued

A CHILD'S WARDROBE

Day and Night Wear: Cutting, Drafting and Making. Frocks. The Sailor Blouse. Kilted and "French" Frocks

By AZÉLINE LEWIS

HAVING provided garments for the infant, we will proceed with those required from the toddling stage till three to four years old.

The remarks already made as to allowance for growing must be observed in these, as, indeed, in all children's garments, but more particularly in the very early stages of existence when growth is very rapid. All neck, waist, and wrist bands should be large enough, but not exaggerated, which remark applies also to the size, as over-much fulness means added weight and consequent discomfort to the child.

This brings us to another important point. As the infant grows so its activity increases, and it is then able to keep up the circulation and the warmth of the body by movements. The clothing, therefore, should be light and sufficiently warm, but not too warm, as this induces perspiration and fatigue. The flannel for the underwear should not be of a heavy or close kind, whilst the material selected for the petticoats and frocks should also be of a light make.

Fussy or starched frilling round the neck should be avoided, and, from the point of view of the child's health and comfort, the simpler the garment the better.

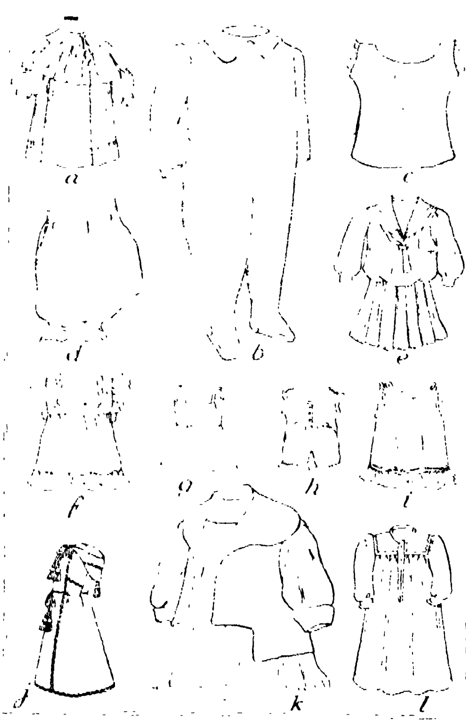
Day and Night Wear. The little woolly vest is still worn under the little chemise of finest cambric or longcloth. The latter, however, in a woollen clad baby's wardrobe, would be of the finest wool or nuns' veiling, when the vest would be dispensed with.

For the first year, the pilch No. 1 is required, also the stork pants, which may be needed a little longer. After this the little drawers shown in 21*d* are better. A little stay bodice of cambric, or soft woollen material, is worn over the chemise, made to flap over somewhat after the style of the bodice for the long flannel in 1. A knitted one, however, is preferable, as it is so much more elastic.

The little flannel petticoat is attached to this, whilst the upper one is better made all in one, or buttoned on to a bodice of the same material. In America a little suspender bodice for the diapers finds much favour. This is made like a little chest protector back and front with elastic at the lower edge.

Over the second petticoat comes the frock, and indoors a dainty cambric pinafore would be worn.

A small dressing gown is a welcome addition to the wardrobe after the first year, and the Dominican shape in the sketch is a very comfortable little model [21*j*].



21. CHILD'S OUTFIT

With respect to night attire, the sleeping suit is undoubtedly the best for the active little mites, and, as a [illegible] even at night [illegible] shape is the [illegible] one to two [illegible] years of age [illegible] the entire body [illegible] prevent chills [illegible] of course, made of flannel. As the child is now able to sit up, there is not the same objection to passing the clothes over the head as in the case of a tiny infant, but it is advisable that they should be easily and quickly [illegible] with a simple [illegible] and turning [illegible]

The n[illegible] most usual [illegible] a child from [illegible] years are sho[illegible] (*c*) shows the small chemise which can be worn at this age, though many mothers prefer the little combination garment shown at (*h*); (*g*) gives a flannel petticoat with shaped skirt part and little bodice to match, feather-stitched round the edges; (*i*) is the most usual shape of over petticoat cut in one, princess fashion, and trimmed with tucks, feather-stitching and embroidery; (*l*) is a small nightgown, with square yoke, made of longcloth, flannel, nun's veiling, or Scotch wincey, which both washes and wears admirably, and is equally useful for frocks as well as underwear. In (*b*) we have the footed

sleeping suit already referred to, whilst (*j*) shows the dressing gown—of Dominican form—which makes a very cosy little wrap for a tiny tot.

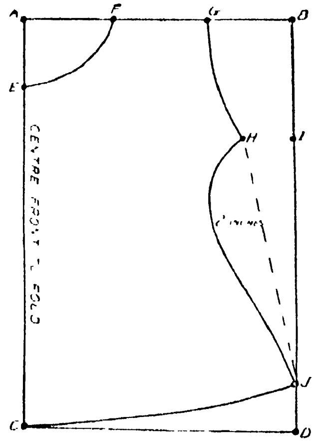
Yoked frocks are the same as those for the first stage, so at (*e*) we have only selected a little sailor frock as a model; (*k*) shows a little matinée coat, and (*a*) a long sacque coat with cape, whilst (*f*) depicts a simple little pinafore with square embroidery yoke; (*d*), of course, shows the little drawers.

Various alterations and modifications arise from time to time, but in the main the patterns remain the same, and those selected are the usual shapes. As far as the coats are concerned, the alteration usually affects the collar or neck portion, and the trimming generally.

For the hygienic "second-stage set" the same principle should be followed as in the first, and the same models may be used with the necessary abbreviations of skirt and enlargement of bodice. The garments should fasten alternately, as already mentioned.

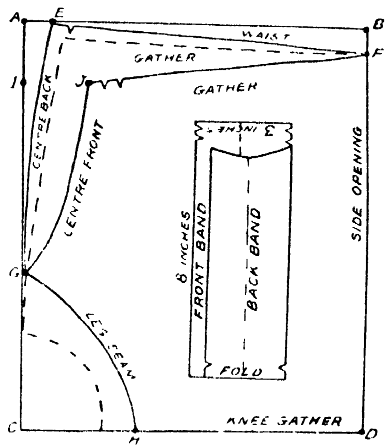
The Drafting. We will now consider the diagrams for the clothes mentioned. The chest measurement may be from 22 in. to 26 in. Neck, 10 in. to 12 in.; wrist, 6 in. to 8 in. Length from [illegible] 20 in. to [illegible] according on the [illegible] the Dutch [illegible] this, of [illegible] ger. [illegible] s the first [illegible] will require [illegible] material to [illegible] over with [illegible] re and fold [illegible] C to D are [illegible] and B to D [illegible] to E, 2 in.; A to G, 5½ in.; [illegible] to H, 1½ in.; [illegible] Curve from [illegible] H, and H to J [illegible]

[illegible] chemise may be [illegible] the shoulder, or [illegible] nt, as preferred; in the latter case, [illegible] ould be slit down and hemmed. If [illegible] athered round the neck, add on [illegible] more inches to centre, and carry the slopes of E and C to meet this.



22. CHEMISE

In 23, we have the second stage drawers, the pitch illustrated in No. 20 being considered the first. For these, ½ yd. of 36 in. material will be required for one pair, if tiny pieces be joined on at front leg. A to B and C to D, 10½ in.; A to C and B to D, 13 in.; A to E, 1 in.; B to F, ¾ in.; A to G, 8 in.; C to H, 3½ in.; A to I, 2 in.; I to J, the same. Curve from E and J to G and G to H, and from F to G. As these two patterns are quite easily enlarged, they are not given again.



23. FIRST KNICKERS

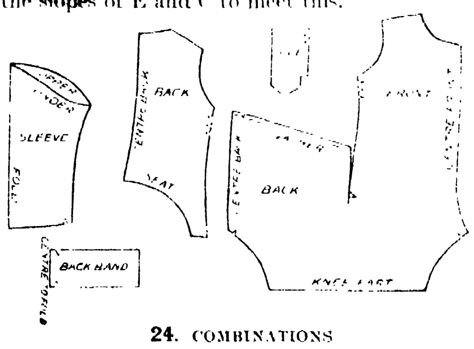
The broken lines indicate the direction to be taken for the divided skirt [see later], which is advisable for some, if not for all children, either of flannel to replace the ordinary shape of flannel petticoat, or cambric. If prettily festooned or tucked, and trimmed with lace at the bottom, it has all the appearance of a petticoat, with the extra advantage of warmth to the lower portion of the body.

The combined garment is now preferred to the chemise and drawers, though one of woven material is usually worn under this. The small garments, however, are rather expensive for their size, as children so rapidly grow out of them. For the very first size, an ordinary vest does excellently, cut to form short leg pieces, then joined up, with the neck either drawn in by a ribbon, or cut at the side to form the head opening, and bound with washing ribbon.

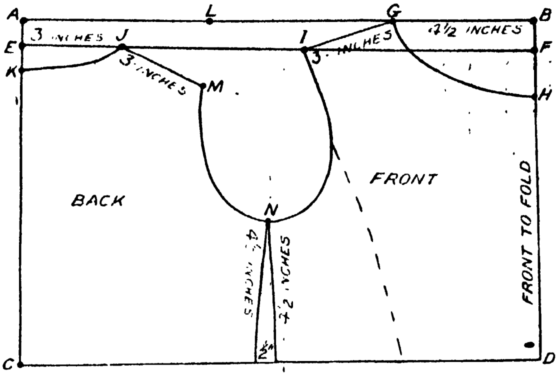
Diagram **24** shows a very comfortable pattern for combinations, which should not present much difficulty in cutting out with the aid of the preceding diagram and instructions.

They are 23 in. from shoulder front to knee, and 20 in. from centre-back to point of leg in front, and will take 1 yd. of 36-in. goods.

The curved lower portion of back, it may be pointed out, is to give room and as a protection for the sides, and must be joined to the front exactly as the notches indicate. These are made of flannel or longcloth, and trimmed according to taste, the opening being back or front as preferred, and may be made with or without sleeves, either long or short.



24. COMBINATIONS

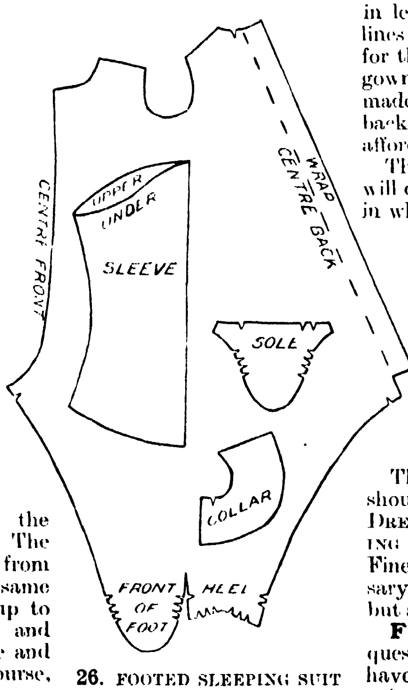


25. DRAFTING BODICE

Diagram **25** gives the drafting of a bodice for the second stage, which will form the foundation for bodice of petticoat, yoke for frock, etc. A to B and C to D, 16 in.; B to D and A to C, 11 in.; A to E, E to K, and B to F, 1 in.; B to H, 2¼ in.; A to L, 5½ in.; L to M, 2 in. The remaining measures are marked on the diagram.

Diagram **27** is the princess petticoat shown at (*i*) in **21**.

This shape requires ¾ yd. of 36-in. material, and, as will be seen by the broken line, is cut from the bodice just drafted [**25**]. If the banded style be preferred, the lower portion is quite easily added on, either in the gathered or circular form. The lower edge may measure from 1¼ yd. to 1½ yd. round. The same model will do for children up to four and six years of age, and can easily be increased in size and length. The trimming, of course, is a matter of taste.



26. FOOTED SLEEPING SUIT

A Child's Sleeping Suit. We now come to the night attire of the little people, from one year old and upwards. As already remarked, for children up to two years of age at least, the footed sleeping suit, made in a soft, light flannel, is the safest form of night wear. Diagram **26** shows the shape of the garment, which is 14½ in. half-chest, and 24 in. across the widest part of leg, the length from shoulder to point of front foot being 36 in. This will take 2¼ yd. of 36-in. flannel.

The foot portion is somewhat complicated, but if the notches be very carefully followed, and those which correspond with each other put together, the making is not difficult.

No. **28** shows at A the foot portion, and at B the foot, heel and sole put together, and the relative position of the notches. The seams are herring-boned with very fine cotton.

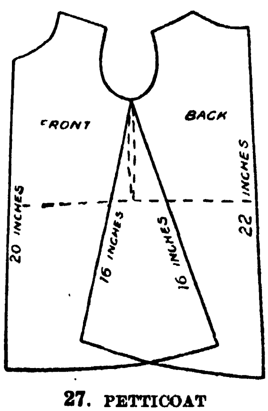
If more protection is required at back and front, a yoke can be added, cut the same shape, and stitched or feather-stitched to the suit, which can be worn by either boy or girl. As for obvious reasons it must be cut somewhat long and large, the foot portion should be drawn in to the ankles by a ribbon or elastic passed through fancy stitching.

After the age mentioned, a nightgown may be preferred, though the male infant will keep to the sleeping suit without feet. Diagram **29** gives a model of a simple sacque affair which, like the princess petticoat [**27**], can be easily evolved from the bodice shown in **25** by increasing it in length and width. The broken lines show the direction to be taken for the skirt part if a yoke nightgown be required. It is better made to fasten either at centre-back, or left side of front, thus affording protection to the chest.

This pattern, it may be noted, will do for the small dressing-gown, in which case, of course, the front would be left open the whole way down. By curving the front neck, if made with a yoke, and adding a wide fold of material round neck, down yoke, and fronts of gown, we shall have a very nice copy of the kimono style. For either shape 1½ yd. to 2 yd. of 36-in. material will be needed.

The making of these garments should present no difficulty if the DRESSMAKING and UNDERCLOTHING Courses have been followed. Fine work, however, is very necessary, not only for the appearance, but also for the comfort of the child.

Frocks. We now come to the question of frocks, and here we have a wide selection as far as make and trimming are concerned, although for the first year or so the choice in cut is chiefly limited to the yoke and smocked styles. The yoke may be at the shoulder only, or may extend below the armpit in the Empire style, both of which are easily cut from our drafting, and the preceding instructions.



27. PETTICOAT

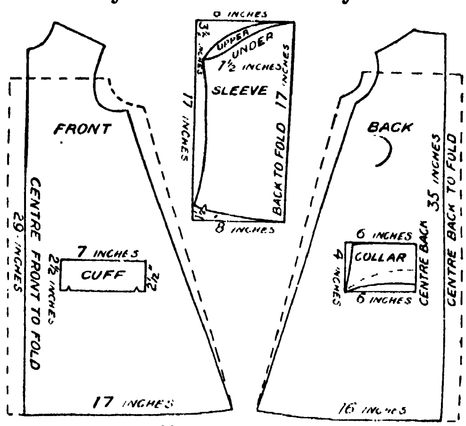
For a rapidly growing child the yokeless smocked frock is decidedly the best, as it expands so readily, but it should be cut with the sleeves carried up to the neck, as in the drafting of the long flannel of diagram 2 [p. 3744], and not with a round armhole. This is an important matter, as the armhole does not expand with the growth, and it is likely to irritate and even hurt the child, besides being more difficult to smock than the other shape, and less effective when done.

A point to be remembered in smocking is that ample material should be allowed for the purpose, as skimpiness detracts very much from the beauty of the work.

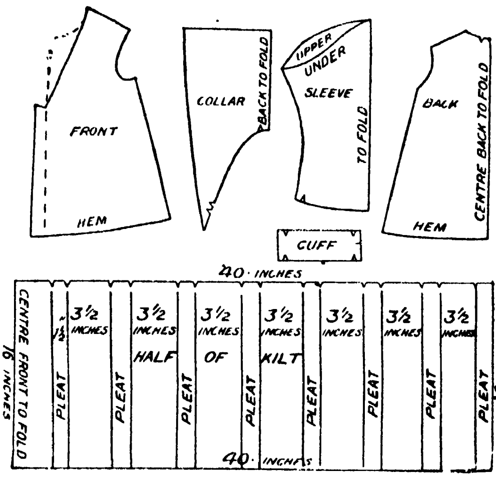
For a sailor blouse, the collar would be of double material, the edge turned in and stitched once or twice, the first row quite close to the edge, the second ¼ in. to ⅜ in. from this. The under part is secured to the edge of blouse, which should have a linen stay to prevent stretching, whilst care should be taken not to stretch either edge.

The seam must be well pressed, when the upper portion can be hemmed over the turnings and again pressed, care being taken with the points of the collar to keep prevent them having a thick appearance.

28. FOOT OF SLEEPING SUIT



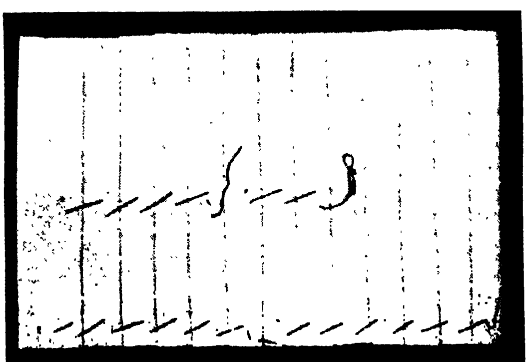
29. NIGHTDRESS



30. SAILOR FROCK

From four to six years of age the yoke and smocked style is usually worn, but may be varied by the long-waisted French variety, or the kilted style, with a sailor or American blouse, equally suited to girl or boy from two and a half years of age.

Diagram 30 depicts a drafting of the latter style, the bodice of which can also be evolved from 25, either high-necked or open, sailor fashion, the former shown by the broken line. Without the collar, and with a box-pleat in the centre, it forms an American blouse. The sleeve can either be put in a cuff, or pleated at the wrist-part to form one.



31. KILT TACKED FOR PRESSING

A Kilted Frock. The kilt fastens at the back, and is hemmed before being pleated. It must be very carefully marked and spaced as shown, so that the pleats are quite even. When tacking, care must be taken to keep the first pleat at the lower edge in a line with the upper one, and with the thread of the material, otherwise each succeeding one will get more on the bias, and the appearance will be spoilt [see 31]. With respect to the material required, this frock will take about 2 yd. of 44-in. goods.

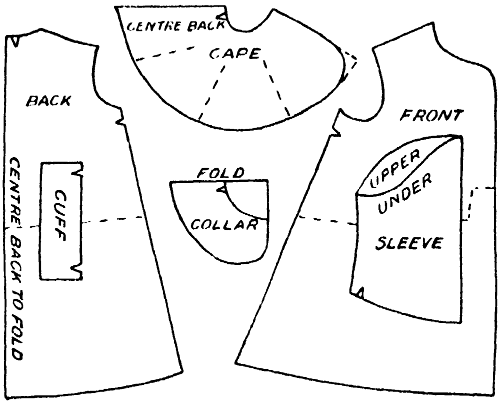
Diagram **31** shows half of kilt tacked and ready for pressing, which should be done on a hard surface; it will take a little time to get the pleats perfectly flat, especially if the cloth be thick. It is best, when doing this, first to put the iron on the bottom edge whilst holding the other taut with the left hand. This will keep the pleat edges straight, which, if the material be at all wiry or thick, may not always be an easy task. When this is so, a second row of basting in the middle is advisable. The kilt is arranged at the waist into a band, which buttons on to a little under-bodice of lining.

This frock is capable of various modifications. If the blouse portion be made a little narrower at the lower edge, and left loose here and at the fronts, it forms the little Quartermaster frock illustrated later, and is worn over the vest bodice depicted with it.

In the long-waisted, or French, frock the bodice portion is carried down a few inches below the waist line, but should not be too low, as this impedes the movements of the child. The making of this style varies considerably, but can be easily accomplished by means of the foregoing diagrams and an approved sketch, and is more fully explained later on. The skirt should never extend below the knee and should also be made a little shorter at the back than the front. Long-skirted frocks are only suited to yoke and banded styles, but whilst extremely picturesque and quaint, are not very practical.

For children of two to four and six years this style will require $2\frac{1}{4}$ yd. to $2\frac{1}{2}$ yd. of 44-in. material, much, of course, depending upon the style and "frilliness" of the frock.

For out-of-door wear after the pelisse is abandoned, the little matinée coat shown at (*k*) in **21** is a very great favourite with most mothers, and is adapted to boys and girls from $1\frac{1}{2}$ to two and three years of age. Many mothers make dainty little slip skirts to wear with these coats out of doors, as recommended for the infant.



32. CHILDS FIRST COAT

For boys, though, a severer style is more suitable. These slip skirts measure $1\frac{3}{4}$ yd. to 2 yd. round, and are just gathered into bands 1 in. or so wide, and fasten on like the ordinary old-fashioned petticoat; or they may be fastened by means of ribbons over the shoulder, as in the baby's slip skirt shown in diagram **1**, which, if crossed over at back and front make a pretty finish. For winter, if the long sacque shown in **32** is preferred, it can be made with a cape and worn with a lace or silk frilled collar according to taste. It will take $2\frac{1}{4}$ yd. of 44-in. material, and, as will be easily seen, the above-named matinée coat is merely a shorter edition, with the corners cut.

Headgear. For the first few months, baby boy and girl wear the same kind of headgear; but after then the boys wear hats and the girls hoods or bonnets. These should at first be of such a make and material that they do not cause any inconvenience to the small head, and of the soft, close kind which the French aptly term a "dormeuse."

For boys, hats with or without brims, with a soft ruched cap inside, are worn at first, the cap being omitted as the child grows. After this, cloth tams, "jelly-bags," and Turkish caps, "man-o'-war" and sailor hats are added to the list.

For girls there is a wide choice in styles, which, however, resolve themselves into modifications and varieties of the Dutch or Puritan, and the Directoire, or poke, bonnet. In summer, frilled or floppy-brimmed hats, and dainty, modified poke or sun bonnets are best for small girls, and mushroom shapes as they grow older. In winter, of course, the quaintly pretty Dutch bonnet may be advisable if preferred. [See MILLINERY]

Continued

CYCLOPÆDIA OF SHOPKEEPING

NATURALISTS. Shop, Stock, and Workshop. Buying and Selling. Business Side of Taxidermy

NEWSAGENTS. Varieties of Businesses. Newspapers and Magazines. Delivery Difficulties. Finance. Colonial Newsagents

OIL AND COLOURMEN. Shop and Fitting. Stock and Staff. Licenses. Proprietary Goods

Continued from page 3883

NATURALISTS

The business which, for want of a better title, is called that of a "naturalist," is usually combined with another branch of shopkeeping. The most suitable businesses upon which may be grafted that of a naturalist are those of a furrier and of a dealer in live animals and birds. Sometimes gunsmiths, fishing tackle dealers, antique dealers, and even barbers, house furnishers, and tobacconists, take up the department. The man who adopts it must have a personal taste for it, and a knowledge of and liking for natural history in its various departments.

The trade has depreciated recently from two causes—first, the flooding of the market with cheap, gaudy, and badly-prepared glass shades of foreign birds, whose appearance repels people of taste; and, secondly, the Wild Birds' Protection Act, which protects so many of the species—and rightly so—that the city sportsman has now a great difficulty in pursuing his sport.

Stock. To make a side line in this trade, a shopkeeper must, of course, show specimens of many kinds, and the taxidermist is usually willing to let him have these on terms of sale or return. In exhibiting them, care should be taken to put them in a position so that direct sunlight does not reach them, as the bleaching effect of light will soon spoil both fur and feathers, and ruin butterflies. Glass cases will steam inside from the effect of direct sunlight. Stuffed heads of animals, not in glass cases, and rugs, will require to be carefully freed from dust, which induces the attacks of moths. If the presence of moths be suspected, a brushing with benzoline will prevent trouble. Benzoline must be applied in the open air, on account of its explosiveness, and should be allowed to evaporate well before bringing the specimens indoors.

In towns where there is a good college in the vicinity, some trade may be done in implements and in cabinets for insects and eggs. Insects' eggs themselves had best be avoided, except by those who are able to identify the specimens and their varieties.

Mounting Specimens. The mounting of horns and heads on shields (usually made of polished oak), foxes' heads and hares' heads and feet, as sporting trophies, will be the principal trade in a country town; but care should be taken to ascertain if the specimens brought for preservation are in a fresh condition, especially when the weather is hot or damp. A good test is the brightness and fulness of the eyes. Specimens sent by post or rail should be packed securely in a box, with dry hay or straw, all risk of crushing being avoided.

It is usual to obtain a deposit of 25 per cent., especially from a new and unknown customer. This will be found necessary, as the preparation of the specimens take a considerable time, and the customer's interest in the interval wanes, and there is the risk of having goods left on hand unless the deposit be insisted on. This is particularly so in the case of pet animals and birds, the owner's grief in many instances being assuaged by the acquisition of a living duplicate.

In the event of specimens being received from abroad, especially the tropics, they must be carefully examined, and if there are any live insects, they must be treated with preservatives [see Taxidermy] and stored in a dry place off the floor, away from risk of rats and mice. As a customer very often does not require his collection mounted at once, a charge for warehousing may be made.

Precautions in Packing. All finished work is best delivered without being packed; but if the distance be too great, and a packing case necessary, a charge is made for this. The box for a glass case should be only a few inches larger than the case, and only straight dry straw should be used in packing, care being taken that the pressure is only on the woodwork, and the glass free. Large heads and horns may be packed in crates and fixed by large screws through the backs of the shields, and the horns supported by crossbars of wood.

It will be seen from the foregoing that a certain amount of trade can be done with a very small outlay. The taxidermist will require cash payment for work done, but probably the dealer will be compelled in some instances to give credit, but he must arrange his price to cover that; he will also assume some risk in having work left on hand, but he can dispose of such work after giving due notice to the owner of his intention. A great advantage is that finished work is not perishable if proper care be taken.

It will seldom pay to dispose of goods by auction, unless they can be included in a sale of similar goods—that is, natural history specimens. This can be done by including them in one of the periodical sales, such as are held periodically near Covent Garden, London, W.C., where large quantities of natural history, entomological, and geological specimens are offered, and the dealer can often pick up a small stock

of saleable articles and specimens suitable to his district and trade. In buying, he must remember that the return may not be immediate, and that second-hand articles nearly always require a little outlay for renovation.

Freaks and Curiosities. Curiosities in the way of freaks, such as animals and birds with an abnormal number of heads or limbs, can seldom be sold to any advantage. Goods which sell most quickly are those of the ornamental type, such as mounted horns and heads. The larger and more mature command the best price and the quickest sale. The dealer must be able to detect the species at a glance, and so to judge its proper value.

Dressed skin rugs and feather screens soon show signs of wear, and should be carefully examined for probable spots which moths have attacked.

The sale of native arms, implements, dress, and ornaments, is frequently combined with this trade, but it is difficult to judge if one is buying an imitation made in this country or not. Sometimes a known customer has a surplus lot of curios to dispose of, collected by himself, and authentic; an opportunity of this sort should not be neglected by the dealer.

Prices. The subjoined list of prices may be a guide for general work, but the variation in the requirements of each customer and individual specimens makes it impossible to publish a complete list of charges. The best way would be for the dealer to get an estimate from the taxidermist as the practical man before giving a binding price. The prices quoted are those below which it is impossible to expect good and reliable work.

BIRDS.

	s.	d.
Stuffing small birds, without case, up to the size of a linnet, goldfinch, or canary	2	0
Size up to pigeon	4	0
Size up to grouse	6	0
Size up to pheasant	8	0

Double this for the cost of the bird mounted in plain case.

FRESH WATER FISH.

	Flat glass case. £	s.	d.	Bent glass case. £	s.	d.
Weight 1 lb.		12	0		14	0
,, 2 lb.		14	0		16	0
,, 3 lb.		16	0	1	0	0
,, 4 lb.		18	0	1	5	0
,, 5 lb.	1	0	0	1	8	0

ANIMALS.

	£	s.	d.
Squirrels, without case		5	0
Rabbits ,, ...		10	0
Foxes ,, ...	2	0	0
Double this for casing.			
Fox's head only, on shield		18	0
,, brush, with handle		5	0
Fallow deer's head	2	0	0
Red deer's head	3	10	0

	£	s.	d.
Dressing skin of rabbit			9
,, ,, fox		3	6
,, ,, deer		10	0
,, ,, tiger or lion		0	0
Tiger or lion, with head stuffed and eyes inserted, lined and bordered with felt	3	0	0

Aids to Selling. A photographic album of finished specimens is of great value to convey an idea of the best way of treating them, and will save room, etc., the dealer not requiring to have the objects themselves at hand. This is especially valuable with respect to the mounting of horses', rhinoceros' and hippopotamus' hoofs and feet, which are sometimes mounted in silver, copper, and brass, as inkstands, cigar, cigarette and tobacco boxes, candlesticks, trinket boxes, paperweights and doorstops. Elephants' feet are also made into workboxes, flower-stands, footstools, umbrella-stands, and liqueur stands.

Foxes', hares', and otters' feet (or pads, as they are called in the trade) are mounted as paper-knives, letter clips, whip handles. Deer's hoofs, with part of the leg included, can be mounted as whip handles and hat pegs; a set of four makes a handsome candelabrum. Various animals' tails are utilised as whisks and brushes.

Opening Business. Established in a town, a port in preference, the beginner would, by judicious advertisement, get into touch with the sporting community, with whom his business mostly lies.

The naturalist should be able to use rod, rifle, and shot-gun; and if required to accompany his customers on an expedition for big game, etc., the opportunities for observation, making notes and sketches on the spot, sometimes from life or at all times from fresh-killed specimens, are invaluable. It is quite exceptional for sportsmen to take an experienced man with them, and consequently many a valuable specimen is spoilt by having the skin literally torn off by the natives and roughly dried, taking its chance of hundreds of destructive insects and risks of injudicious packing making it valueless for scientific purposes, as, if mounted, it must be repaired and faked to make it presentable. For a business of this description premises with a shopfront are not necessary.

Workshop. A lofty, well-ventilated workshop with a large stove, water supply and a large sink is necessary. The shop should be big enough to accommodate the largest animals and leave room to manipulate them. A convenient size is about 50 ft. long by 20 ft. wide, with doors 15 ft. high by 8 ft. wide.

The tools required are described in the article on practical taxidermy. To learn the trade a start must be made very young. The boy must show a decided interest in natural history, and have grit to endure the many unpleasant processes and difficulties connected with it.

Apprenticeship is not universal in the trade, the boy usually starting at the bottom of the

ladder, making himself generally useful (or perhaps otherwise) for a small wage, and working up.

The salary for a first-class man is not likely to exceed £3 per week, but if thoroughly scientific and well versed in the requirements of museums, a more lucrative appointment may be obtained.

NEWSAGENTS

In the present state of society the newsagent is as essentially a part of modern life as the printer and the reporter, and there should be no difficulty in anyone with the ambition of becoming a disseminator of news finding a suitable sphere for his activities.

The amount of capital required to start depends entirely on the ideas of the beginner. For instance, he may select a stand in a busy thoroughfare, or a pitch near a railway station, where a constant stream of men passes morning and evening, and, with the expenditure of a few shillings, obtain and dispose of a supply of the morning and evening papers. Or he may ally himself with one particular newspaper, and obtain from the manager a district, which he is expected to work for all that it is worth. The latter class are familiarly known as "hawkers," and some people are squeamish about venturing on such a course. A good wage, however, is usually made right away, and there are no expenses to come off. We have known many a splendid business built up from just such beginnings, the initiative and alertness demanded in this line being an excellent training for future and more extended operations.

The Shopkeeper Newsagent. Presuming, however, that the aspirant wishes to blossom forth at once as a shopkeeper, one of two courses is open to him: first, to acquire a business which, for some reason or other, has come into the market; or, secondly, to select a shop, preferably in some busy thoroughfare. With regard to the former course, that of acquiring a business as a going concern, the utmost caution must be exercised by the buyer, as frequently, despite the specious reasons given by the seller, those businesses which come into the market are either suffering from "dry rot," or have got into the sere and yellow leaf. Assuming that the business is acquired, the first thing to do is to notify the change to the customers and wholesale merchants of your predecessor. This is generally done by joint circular and advertisement. Then call a clearing sale, and get rid, at any cost, of the old stock.

The New Business. In regard to the opening of an entirely new business, the choice of a line to be run along with the news agency will lie entirely with the beginner. We are concerned at present with the newspaper trade only. An advertisement should be inserted in the newspapers circulating in the vicinity, and a neat circular drawn up and addressed to likely parties in the neighbourhood. Do not grudge expense in advertising; money judiciously spent thus is a good investment. It is a wise thing to make a systematic canvass of the district in which the shop is situated and, if possible, to obtain orders for the permanent delivery of the morning and evening newspapers, magazines, etc.

Buying Terms. Where possible, it is always well to deal direct; but any good wholesale house will be pleased to quote terms. As a rule, 25 per cent. is allowed off the ordinary penny and halfpenny papers. On some the dealer may get a little more, while on others he will be allowed less. Of course, he will not get those terms for the sixpenny weeklies, and some of them will cost him 5½d. plus the carriage. It is obvious, therefore, that these are not a source of profit directly. In fact, when carriage is considered, to say nothing of delivery, the balance is decidedly on the wrong side of the ledger. As a rule, newsagents who know their business supply the sixpenny weeklies only to customers for other newspapers or magazines. Pending better terms, it might be wise policy to leave them severely alone. The same remark applies to special editions of "trade" papers, which are issued at certain seasons. It is a good maxim in business to "Let every herring hang by its own head."

Accounts have usually to be paid monthly; but unless good security is given, the beginner must pay cash in advance. As to the class of newspapers wanted, that will depend to a large extent on the locality in which the shop has been opened, and the common-sense of the newsagent must here, as always, come into play. For instance, if the shop be in the vicinity of a school, a good trade may be done in the excellent juvenile literature which is now so plentiful.

The Shop. In order to attract, and what is of equal importance, to retain customers, the shop should have a neat and tidy appearance. The papers should be arranged neatly on the counter, so that the visitor may easily read their titles. A judicious display of show-bills and neat cards may be used with advantage. The windows should be an index of the shop, and have an attractive and inviting appearance. They should be frequently changed, and on no account should the announcement of a Christmas publication be allowed to hang till Easter, nor the advertisement of a Summer Number stare one in the face at Christmas. There is nothing more repellent and detrimental to business than badly-dressed windows. They give one the idea of untidiness and unpunctuality on the part of the shopkeeper—two fatal defects in any business.

The newsagent who is alive will take advantage of the plentiful supply of literature which is freely offered to push the sale of forthcoming newspapers and periodicals, or to give a fillip to those already in the market.

What to Sell. Quite a good trade may be done in the sale of cheap reprints of standard works, and in magazines and periodicals. This is considered a perfectly legitimate part of the newsagent's business. An excellent feature of this class of literature is the increasing number of publications which are now being issued at net prices, and which, as a rule, yield a profit of 15 per cent. This is fair alike to the

public and to those who handle the goods. The purchaser knows that he is paying the market price, while under the discount system he may pay ninepence in one place, tenpence in another, and if he buys at a railway bookstall, the full price of a shilling.

Special editions of the illustrated papers, issued in connection with great national events and at Christmas, are now recognised institutions, as are also the double numbers of magazines and other periodicals. In these the alert newsagent may usually do a good stroke of business. If he is wise, however, he will take full advantage of the advertising matter issued by the publishers and book his orders beforehand. This, of course, means the expenditure of a good deal of time, and also money; but it will pay. He will do well to limit his supply as nearly as possible to the orders which he has received. That is until he knows his district thoroughly, and even then he should be guided to a large extent by this rule; because even old and experienced dealers have again and again been bitten by laying in a heavy stock of "special" numbers in anticipation of the big rush which never came off.

Returns. The question of "returns" should be very carefully considered by the newsagent. On a number of newspapers and magazines a certain percentage of "returns" is allowed. This enables the shopkeeper to stock these publications without running the risk of heavy loss. Of course, it is not fair to abuse the privilege which is thus given by the publishers of these periodicals, etc. The newspaper list should be carefully gone over every week, and scrutinised, and "returns" reduced to a minimum. All non-returnable newspapers left over should be relentlessly cut off, and no papers kept except those for which there are definite orders. The same remark applies with equal force to the magazine list. This must be kept steadily in view unless profits are to be reduced altogether to the vanishing point. An old newspaper or magazine is generally of as much value as, say, last year's almanac. The newsagent must pay the carriage on his "returns." Some publishers are now accepting the headings of old news, papers in lieu of the newspapers themselves-thus saving the newsvendor the carriage charge.

Profits. The question "What profit can be made?" is the most important of all. In arriving at a satisfactory answer there are a good many points which must be considered. Of course, the first is the price at which goods may be obtained. As already indicated, 25 per cent. is allowed off the ordinary penny and halfpenny newspapers; some publishers allow a little more, while a considerable number allow only about 15 per cent., and in the case of the sixpenny weeklies, most of the publishers allow only 7½ per cent. Put it down at say 20 per cent. on newspapers over all. Taking net and non-net magazines together, say 10 per cent. Now, let us take a business turning over, say, £600 a year, £500 of which is newspapers and £100 magazines and other periodicals. We have thus a gross profit of £110. Let us see what expenses have to come off.

Delivery. Take first the cost of delivery; and with the advent of the halfpenny paper, the question of delivery has come to be a serious matter, because the newsagent has to pay the same for delivering a halfpenny paper as he has for delivering a penny one, while his profit is only one-half. Then, as districts are often widely scattered, and distances at which the papers have to be delivered considerable, this necessitates a number of errand boys. If 10s. a week—that is, £26 a year—be allowed for these, the estimate is moderate; a girl to attend the shop and look after the books, say another £26 a year.

Then carriage is a very heavy item. On a business such as we have supposed, it would amount to no less than £12 a year. There is thus left the sum of £46 to pay the newsagent's own wages, rent, taxes, light, and fuel, to say nothing of postages, advertising, and leakages. Not much prospect there of soon amassing a princely fortune. It may be pointed out that in the large towns, where there is a wholesale house, the newsagent is in a much better position than his brother in the country, in respect that he has no carriage to pay; and the bigger the town the better prospect there is of a larger cash trade being done. On the other hand, however, to balance this, the rent in the metropolis and other large cities is much higher than in provincial towns.

Charges for Delivery. In the good old days when the customer was content to wait the pleasure of the newsagent in delivering his paper, something might have been, and no doubt was, made at the business. Now, when every customer wants his morning or evening paper as soon as it is published, or immediately after the arrival of the train, it comes to be a question, unless delivery is charged for, whether the game is worth the candle.

A good many towns in England, and a number of Scottish towns have adopted the charge for delivery, and the arrangement has worked well. It might, therefore, be advisable for the newsagents throughout the country to take the matter up and devise means by which concerted action might be taken. It is more than likely that the public would at once fall in with the suggestion. Men like and expect to be paid for their own work, and do not, as a rule, object to those who work for them receiving a fair wage.

Work of the Newsagent. Anyone going in for the newsvendor business must make up his mind for a life of hard work and strenuous endeavour. It is not the line for the Tired Tims and Weary Willies. To do the work thoroughly he must be up early and work late. He must go to the publishing offices or attend the arrival of the early morning trains himself and see that his army of boys are all forward and supplied with the papers for their various districts; and, in the event of one or more not turning up, he must arrange for others to take their places—a rather difficult matter. The morning papers must all be delivered before breakfast, or before business men go to their offices.

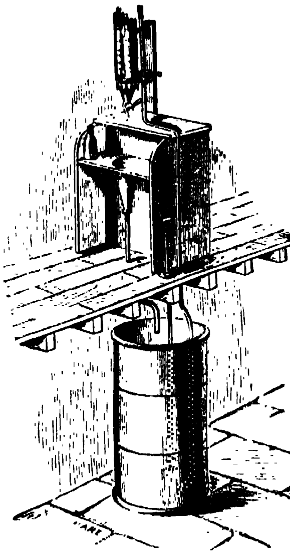
The echoes of the machinery which produced the morning papers have hardly died away when the whir of the presses throwing off the evening papers is heard. The earliest editions of the evening papers are out before midday; and edition after edition, including Special and Football, is poured forth until late in the evening. This goes on day after day without intermission from January to December. There is no business in which there are more worries and petty annoyances. The newsagent will have much to try his temper, and while avoiding servility on the one hand will find the business of the newsagent an excellent school for cultivating the virtues of patience and courtesy, without which he will inevitably fail.

The Colonial Newsagent. In the Colonies, and notably Canada, the newsagent's business is a much more lucrative one than it is in the old country. This is true especially of the western provinces, where the coin unit is 5 cents. Although the face value of a newspaper is one cent, it cannot be bought for that price. Of course, if delivered by the publishers the face value only is charged; but if a one cent newspaper be bought on the street, or in a shop, the charge is 5 cents—the Irishman's modest 5 per cent. profit. Even in the west, however, the spirit of competition is developing, and the newsboys are beginning to cut the price. The visitor will be not a little amused when accosted by the pushful youngster to buy the evening paper, and as a special inducement is offered "two for five." Until recently the rate at which newspapers were supplied to the newsagents was two copies for one cent. Lately, however, in April, 1906, the proprietors, who did not see the fun of all the profit going one way, raised the price to one cent per copy, which still leaves, at five cents a copy, or even "two for five," a handsome profit to the newsagent.

OIL AND COLOURMEN

In the days of home-made tallow candles, "farthing dips," and 'a'penny rushlights, the tallow-chandler frequently carried on a distinct trade, his wares being mainly candles and soap. In his minute investigation of London trades, Mr. Charles Booth found this calling no longer in separate existence; the soap and candles are now sold by the grocer or the oilman. The oilman himself, who once dealt mainly in paints and paint oils, now sells illuminating oils, paints and paint oils, brushes, varnish, baskets, lamps, candles, soap, and also, very commonly, tinned and potted goods, which cannot be injured, like groceries or provisions, from shop contact with the more odoriferous goods. Ironmongery, garden tools, china and glass, mats, buckets, brooms, grocers' sundries—it would be a long list that exhausted the goods conjoined in modern oil-shops in London and elsewhere. The "Practical Grocer" (Gresham Publishing Company) devotes several chapters to the oilman and the goods he deals in.

Starting in Business. A capital of about £200 should be sufficient, if the beginner is a practical man. The choice of stock will depend a good deal upon the ascertained needs of the neighbourhood, but an oilman's stock is always of a highly miscellaneous character. It is usually found the best plan to specialise in one or two particular departments of the business, and in those to carry as far as possible a completely representative stock; although in buying such stock the beginner with limited capital must not forget that some small items may have to lie in stock for a long time before being asked for by customers. All such goods should therefore bear a high profit.



OIL-PUMP AND MEASURING APPARATUS

Oil Licence. A preliminary question is whether or not a licence will be required under the Petroleum Acts. This depends upon whether or not the oil sold has a "flash-point" below 73°F. "Petroleum," in the meaning of the Petroleum Acts, is rock oil, Rangoon oil, Burmah oil, oil made from petroleum, coal, schist, shale, peat, or other bituminous substance, and any other product of petroleum, or any of the abovementioned oils, which, when tested in a prescribed manner, gives off a vapour inflammable at a temperature less than that stated. Oil for burning in lamps ought never to flash at a temperature less than 73°F., otherwise it is too dangerous for ordinary use. Therefore the oil usually sold is not subject to the Petroleum Acts, and its sale necessitates no licence. Petroleum spirit, benzine, petroleum ether, and similar articles, come under the Acts, and can be stored, transported, or sold only under licence from the local authority. Carbide of calcium, used for making acetylene, etc., needs a licence, if more than five pounds be kept, and this quantity must be in separate sealed metal vessels, each containing not more than one pound. Methylated spirit needs a special licence, must be sold in bottles marked with its name, and must not be sold between 10 p.m. on Saturday and 8 a.m. on the Monday following. Fireworks come under the Explosives Act, and shops where they are sold have to be registered [see Gun and Ammunition Dealers]; they must not be sold to children under thirteen.

Storage. The storage of the oil is the chief matter in an oil-shop. The safest plan is to have an underground tank, capable of holding 150 gallons or 200 gallons, in the yard outside the shop, the oil being carried from it into the shop by a pipe under the floor, which supplies a kind of "engine" or pump, with a measuring

siphon. The metal tank should be hermetically closed, with the exception of an air-hole, which should be covered with very fine copper wire gauze. If it is not possible to have the tank outside the shop, it may be placed in the cellar, providing there is ventilation. The accompanying illustration shows an arrangement by which oil may be drawn from a tank in the cellar into a measuring cylinder, which shows the quantity, and allows sales to be made without handling measure or filler. Turpentine is usually kept in metal drums. Vegetable oils should be kept in a cool place, and covered.

Such goods as matches may be stored on shelves, but keep them well away from the gas-jets or other lights. Candles should not be placed on the upper shelves—these are likely to be the hottest part of the shop. A stand or an enclosed glass show-case may be used for displaying long-handled brooms and brushes. Small wares can be kept in drawers or boxes, arranged so as to classify them conveniently. Very often they can be kept in parcels, to save deterioration. On the top of each drawer or box put a card indicating the contents. It should be noted that when edible goods are stocked they should be kept away from others the smell of which may affect them. Pickles and curry powder in bottles are best not exposed in windows, the contents being affected by the light. Note also that such goods as whiting draw moisture when in paper parcels, and not in bags; while others, like washing soda, evaporate.

Cautions in Trading. In view of the requirements of the law, it is well to bear in mind that oils and other goods are sometimes adulterated, so that the retailer handling them may incur risk quite innocently. Particular care is necessary in seeing that oils intended for consumption as food, or with food, are vegetable, and not to any extent mixed with mineral oils. A guarantee of genuineness should therefore always be insisted upon when buying such oils. If "sweet" oil be asked for, mineral oil must on no account be supplied. If "olive" oil be demanded, cotton-seed oil will not serve as a substitute. If the retailer is at all doubtful of the genuineness of his "olive" oil, he should sell it only as "salad" oil, or he may be caught when he least expects it. In regard to vinegar, again, if "malt" vinegar be asked for, malt vinegar must be supplied, and not acetic acid or wood vinegar. Note that tinned goods are apt to deteriorate sometimes, although when properly prepared they may keep for years unaltered. Stock of this kind should be carefully inspected at regular intervals for the discovery of "blown" or puffed-out tins, this puffing being the result of the formation of gas from the decomposition of the contents. It goes without saying that such tins should be immediately withdrawn from the stock; indeed, it is not safe to keep them on the premises, since discovery by an inspector would involve the retailer in appearance before the magistrate to answer a charge of having unsound food in his possession. Washing soda, again, is an article that has involved oilmen in trouble, owing to its adulteration with Glauber salts—which "won't wash." The leading firms are usually willing to analyse doubtful samples.

Oil-shop Sundries. These include a bewildering variety of such goods as metal polishes, boot polishes, blacklead, bathbrick, furniture polishes, inks, blues, cements, glue, size, etc. Oilmen often have such articles made and put up for themselves. Many useful recipes will be found in the "Practical Grocer," already named, and in "Law's Grocer's Manual" (Gilbert and Rivington, Ltd.); while a number of collections of the kind are issued by the proprietors of the "Oil and Colourman" and "Oils, Colours, and Drysalteries."

Staff. Managers of branches in London expect about 30s. per week salary and rooms for branch doing £20 a week; 35s. for shop doing £20 to £30; 40s. for shop doing £30 to £50; above this 1¼ per cent. extra. The wages of assistants are usually: First hands, 25s. to 30s.; second hands, 21s. to 25s.; porters, 20s.; boys, 10s. a week. A little extra is sometimes given as good-conduct pay if all orders are delivered in reasonable time and without complaints from customers. In some instances the rules specify: Shops opened at 8 a.m., closed 9 p.m.: Thursdays, 2 p.m.; Saturdays, 10 p.m.; branches have check tills, and the manager is responsible for the takings, with a percentage on net profits; managers, assistants and boys wear white coats and aprons, and boys sometimes have caps with the proprietor's name upon them. Managers render an account once a week of takings, expenses, and goods received and returned. Yard and cellars are cleaned and trucks washed weekly.

Proprietary Goods. It may be useful to the beginner to note that, if he has not sufficient practical knowledge of such departments as paints to handle material in bulk, he may still make a fair show, so many articles dealt in by the oilman and grocer being now put up by the manufacturer as proprietary articles, ready packeted or canned, with full directions for use. The number of such proprietary goods included in the list of some retail stores literally runs into thousands. Soaps, candles, ready-mixed paints, oils, matches, blacking, and similar sundries, firelighters, screws, tacks, pickles—it is difficult rather to say what is not packed than what is. Moreover, the retailer may himself possess proprietary brands if he chooses, a number of firms laying themselves out for this class of business. Needless to say, the profits on proprietary articles not the retailer's own brands are commonly exiguous, and with many of them there is no small trouble, owing to the various schemes of present-giving, coupon distribution, and so on, which are adopted by the proprietors to push their goods with the public and create a demand which almost compels the retailers to stock them. A large number of the most important, however, are now protected by the Proprietary Articles Trade Association, which secures to the retailer his fair profit.

Continued

NORTH AMERICA

Physical Features, Climate, Vegetation, Occupations and Races. Canada and the Great North-West. The Eastern Provinces. The C. P. R.

Group 13
GEOGRAPHY
28

Continued from page 3902

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

AMERICA, or the New World, consists of two great peninsulas—North America (8,000,000 sq. miles) and South America (7,000,000 sq. miles), united by the long, narrow isthmus of Central America.

NORTH AMERICA

At the Isthmus of Tehuantepec, which may be taken as the southern limit of North America, the distance across is 130 miles. Rather less than 4,000 miles due north is Cape Murchison, the most northerly point of the mainland. The maximum breadth of the continent is about the same. The whole of the north, except Alaska, is British, forming the self-governing colonies of Canada and Newfoundland. South of Canada is the Republic of the United States, to which belongs Alaska. South of the United States is the Republic of Mexico.

Oceans, Seas, and Gulfs. The northern shores are washed by the Arctic Ocean, the western by the Pacific, and the eastern by the Atlantic. An archipelago of islands stretches across the Arctic Ocean north towards the Pole, and east towards Greenland, which is separated by Baffin Bay from the North American mainland. In the extreme north-west, America is less than 40 miles distant from Asia across Behring Strait. The Aleutian Islands, off Alaska, continue the island fringe of Eastern Asia.

The coast of North America is much indented. On the Atlantic coast, which has marginal lowlands, are (1) Hudson Bay; (2) the Gulf of the St. Lawrence, entered north or south of the island of Newfoundland, and leading to the great lakes of Ontario, Erie, Huron, Michigan, and Superior; (3) the Gulf of Mexico. The latter, with the Caribbean Sea, which is almost cut off by the island of Cuba, is sometimes called the American Mediterranean. The islands which define its eastern limits are the West Indies. Let us look out all these on a map, and notice the names of the straits leading to them. On the Pacific coast, which is bordered by high mountains, there are fiords in the north like those of Western Scotland or Norway in the north-west. In the south is the Gulf of California, the largest gulf on the Pacific coast. It may be contrasted with the Atlantic gulfs.

Mountains. The highlands and lowlands of America are arranged in parallel belts. Along the whole length of the Pacific coast runs a continuous belt of broad high mountains, sometimes called the Cordilleras. These sink in the east to a broad, rolling plain, which extends from the Arctic Ocean to the Gulf of Mexico. Two breaks occur in its surface, which elsewhere slopes imperceptibly but uniformly from west to east. The first of these is the region west of Lake Superior. Though nowhere over 2,000 ft. high, it gives rise to the St. Lawrence, flowing due east to its gulf; the Mississippi, which flows almost due south across the central lowland to the gulf; and the Red River, which flows north to Lake Winnipeg. The second is the Ozark Mountains, which separate two of the parallel tributaries of the Mississippi which rise in the east. In the east the Central Lowland gradually rises to the Atlantic or Eastern Highlands, which, under various local names and with some breaks, can be traced from Hudson Bay almost to the Gulf. North of the St. Lawrence they are known as the Labrador Highlands, south of the St. Lawrence as the Appalachian Highlands. These highlands fall steeply on the east to the Atlantic lowland, which widens towards the south, and is connected round the south of the Appalachians with the central lowlands, there forming what is often called the Gulf Coastal Plain.

Rivers. From this arrangement of highlands and lowlands it follows that we shall have a series of (1) short rivers flowing west to the Pacific; (2) long rivers from the eastern slopes of the western mountains, flowing east or south; (3) long rivers from the gentler west slopes of the Appalachians, flowing west; and (4) short Atlantic rivers from the steep eastern slopes of the Appalachians. The rivers from the central heights have already been named.

The longest of the Pacific rivers flow for considerable distances parallel to the mountain chains. Of these, the chief are the Yukon, flowing to Behring Strait in a long, narrow valley parallel to the coast; the Fraser and Snake-Columbia, flowing to the Pacific from the central region of the western mountains; and the Colorado, flowing to the Gulf of California.

The northernmost of the long rivers flowing east is the Mackenzie, flowing with a course nearly parallel to that of the Yukon through Athabasca, Great Slave and Great Bear lakes to the Arctic Ocean. Parallel to its upper valley are those of the Saskatchewan, which flows east to Lake Winnipeg, and thence, as the Nelson, to Hudson Bay, and those of the great rivers which flow east to the Mississippi, the Missouri, Platte, Arkansas, and Red River. The Mississippi also receives the waters of long west-flowing rivers from the eastern Appalachians, which are gathered up and carried to it by the Ohio. Of the short, rapid rivers of the Atlantic seaboard the most important are the Connecticut, Hudson, Delaware, James, Potomac, Susquehanna, and Alabama.

Ease of Water Communication. No other continent has such admirable facilities for

water communication. North America is covered by a network of lakes and rivers, separated by inconsiderable distances, permitting easy water communication in all directions. The Great Lakes, with the St. Lawrence, open up the very heart of the continent. Lake Erie is quite near the Ohio tributary of the Mississippi. Lake Superior is even nearer to (1) the Winnipeg-Nelson system of lakes and rivers ; and (2) the Mississippi. A very short canal thus gives through communication between the Gulf of St. Lawrence and the Gulf of Mexico. The source of the Mississippi is only a few miles distant from that of the Winnipeg or Northern Red River, and the three systems, St. Lawrence, Northern Red River, Nelson, and Mississippi may almost be regarded as one great system, linking together the three great Atlantic gulfs. The Mackenzie is easily reached from the Saskatchewan, thus giving access to the Arctic Ocean ; but as it is frozen for many months of the year, this is of little practical importance.

The Western Mountain System. It is impossible in our limited space to study this great system in detail. In the east, the lofty Rocky Mountains rise steeply from the plains. West of these are a series of plateaux, or basins, and west of these again another series of ranges, locally known under different names. An outer coastal range is less well marked, but can be traced on the mainland and bordering islands.

The basin of the Yukon is separated from the Mackenzie by spurs of the Rockies. West and south of the valley are two parallel volcanic ranges, the northern forming the mountains of Alaska, which are connected through the Aleutian Islands with the volcanic highlands of East Asia. Mount McKinley is the highest point in North America north of the Yukon. The southern range is a labyrinth of glacier-filled valleys and snow peaks rising precipitously from the sea, the highest being St. Elias (18,000 ft.) and Logan (19,700 ft.). Over the wild southern mountain chain difficult passes, closed by snow for many months, lead to the gold-mining districts of Klondike and other centres in the Yukon basin.

British Columbia. British Columbia is a high, rugged plateau enclosed between the Rockies on the east and the Northern Cascades on the west. Beyond the Cascades a coastal range appears in the islands of Queen Charlotte and Vancouver. Where they are crossed by the Canadian Pacific Railway the Rockies are a broad system, consisting of the Summit, Selkirk, and Gold ranges. These parallel ranges are separated by long valleys in which flow the tributaries of the rivers running west. The easternmost or Summit range of the Rockies rises in sheer cliffs or escarpments above the plains, towering up in rock walls 3,000 or 5,000 ft. high. The highest summit, Mount Columbia (14,000 ft.), overlooks the sources of the Athabasca, flowing to the Mackenzie, the Saskatchewan, flowing to Hudson Bay, and the Fraser and Columbia, flowing to the Pacific. Many peaks rise to 12,000 ft., and vast glaciers and snowfields feed the rivers. The forests are much thinner than in the Selkirks, whose fine combination of forest, glacier, and snow peak has earned the title of the Switzerland of America. The Gold and Cascade ranges are lower, and forested almost to their summits. Across these ranges, which presented great difficulties to the railway engineers, the rivers have cut deep, gloomy cañons in which a raging river boils along at the base of perpendicularly steep walls of rock.

Western Mountains of the United States. The Rockies and Cascades continue south into the United States, diverging as they go. The Rockies become an intricate system of parallel ranges, which enclose high intermont valleys, locally called parks. They form the continental divide between the Atlantic and Pacific rivers. Within a relatively small area are the sources of the Missouri and Yellowstone tributaries of the Mississippi, the Snake tributary of the Columbia, the Green and Grand head streams of the Colorado, and the Rio Grande del Norte. There are spots on the Divide where the sources of two streams, one flowing to the Atlantic, the other to the Pacific, are hardly 200 yards apart.

The Yellowstone Park. The finest of these parks, set apart for national enjoyment, is the Yellowstone Park, some 75 miles square, situated on the Great Divide, about 7,000 ft. above the sea. Surrounded by an amphitheatre of mountains, and containing magnificent cascades, beautiful lakes, many geysers, hot springs, and wonderful coloured sinter terraces, it forms a natural museum unique in the world.

Far surpassing everything else in beauty is the Yellowstone Cañon, into which the river falls over the famous Yellowstone Falls. In places the walls of the cañon are 1,500 ft. high, while the width of the chasm is only half a mile. It has been cut down by the river through pale yellow or pinkish rocks, and the rocks do not weather uniformly. All along the cañon walls the harder parts project in a series of massive fretted buttresses and jagged pinnacles of the most fantastic shapes. "The whole gorge is painted in the most brilliant hues, from pale lemon yellow to deep orange, streaked with warm vermilion, crimson and purple, which, mingling with the deep green of the pines that clothe the brink of the chasm make up a picture of transcendent beauty."

Somewhat similar cañons are cut by the rivers south of the Yellowstone, where Long's Peak and Pike's Peak are both over 14,000 ft.

Idaho, Utah and Colorado. West of the Rockies lies the lava desert of Southern Idaho, cloven by the deep gorges of the Snake and Columbia Rivers. In their descent they pass over many falls, of which the Soshone Falls of the Snake are the finest. South of the Snake is the Great Basin, a district as large as France, whose waters flow to the Great Salt Lake, and other basins without an outlet. The surface is covered with short ranges of tilted block mountains, varied in colour and bare of vegetation. Between these are wide valleys covered with dry scrub, or with nitrates and other alkaline deposits. Under irrigation the

139. NORTH AMERICA

soil is very fertile, and the region round Salt Lake City is a veritable garden. The Wahsatch Mountains separate the Great Basin from the Colorado plateau to the east. This region consists of high arid plateaux, above which rise table-shaped mesas, or steep-sided pinnacle-shaped buttes. The Colorado and its tributaries flow in cañons similar to that of the Yellowstone but on an infinitely vaster scale. The Marble Cañon in the Painted Desert of Arizona, and the Grand Cañon of the lower Colorado, 300 miles long and in places a mile deep, are the most wonderful. This extraordinary region long baffled exploration, and is still imperfectly known. All these regions are arid, and bare of vegetation. West of the Colorado, in the lee of the Sierra Nevada, the country becomes a desert, where such names as Death Valley, a region of enormous mineral wealth, tell their own sinister tale. It is a land of burning sands, weird, distorted cactus vegetation, mirage and thirst.

The Western Rampart. The western rampart of these vast plateaux and basins is formed by the Southern Cascades, the Pacific slopes of which are densely forested. By intercepting the rainy winds they produce the arid conditions just described. Of many volcanic cones the finest are Tacoma, Hood, and Shasta (14,500 ft.), beyond which the system is continued south by the Sierra Nevada. Across the Southern Cascades there is only one natural route, the gorge of the Columbia, which cuts its way to

the sea between great basaltic cliffs in places 2,000 ft. high. The Sierra Nevada contains many peaks over 13,000 ft., whose snowy summits have suggested its name. Hidden between its parallel ranges is the Yosemite Valley, one of the beauty spots of the world. It is enclosed between rock walls of stupendous height, over which the rivers leap in magnificent cascades, the wonderful panorama of crag, forest, and cascade being mirrored in the lovely lakes of the valley floor. Between the Cascades and the Coast range is the fertile Willamette valley of Oregon, whose northern extremity forms Puget Sound. Between the Sierra Nevada and the Coast range is the rich valley of California, drained by the Sacramento.

In Mexico, the Rocky Mountains are continued by the eastern, and the Sierra Nevada by the western Sierra Madre. These form the margins of the Mexican plateau, which rises to the south, where the Sierras converge to a great volcanic chain, containing many lofty snow-clad active and extinct volcanoes. The highest are Popocatepetl and Orizaba (18,000 ft.). Beyond this the mountains sink gradually to the Isthmus of Tehuantepec, which is less than 500 ft. high.

The Great Plains. The central plains of North America extend from the Arctic to the Gulf of Mexico. In the extreme north they are a tundra region, covered by a network of lakes. This passes at the south into forests, and these in turn into grasslands. In the United States the eastern forests have been largely cleared, and rolling treeless prairies form a monotonous landscape. Some unfertile tracts occur, such as the Bad Lands of South Dakota, and the Staked Plain of Texas. Along the Gulf of Mexico the plain is of alluvial formation, and fringed with swamps and lagoons. The peninsula of Florida consists of porous limestone, through which the rivers sink. The southern part forms the Everglades, a region of forested waterways and islands. The Atlantic plain is wide and swampy in the south, but becomes narrow in the north.

The Appalachians. These stretch from Newfoundland to within 200 miles of the Gulf, averaging 450 miles in width. Newfoundland, an island of low mountains and many lakes, is cut off by the Gulf of St. Lawrence from the very similar New Brunswick and Nova Scotia.

In the United States the rugged New England Highlands are separated by the Hudson valley from the Appalachian ranges, in the narrower sense of the term. The Appalachian system, which is in reality a very ancient plateau dissected out in the course of ages into parallel ranges separated by long narrow parallel valleys, becomes higher, broader, and more rugged. To the east is the Blue Ridge, and to the west the Alleghany Plateau. The structure of the region in its present form is very complicated. The ranges have local names, which can be looked out on the map.

These broad, rugged, and densely forested highlands long prevented the westward extension of colonisation. The rivers descending from the eastern slopes, which front the Atlantic plain as steep escarpments, did indeed lead to excellent passes, but these gave access only to trough-like valleys, beyond which rose a barrier similar to that just crossed. Population for 150 years moved up and down these valleys, but could not push westward into the central plains, except in the north, where the only natural break across the entire breadth of the highlands occurred.

The Gateway of the Appalachians. This gateway of the Appalachians was the Hudson valley, a great natural opening shut in by the escarpments of the plateau on either side. Nowhere 200 ft. high, and occupied by the Hudson and Lake Champlain, it opened a natural route to the St. Lawrence, and thence by the great lakes to the west. The importance of this route is shown by the enormous prosperity of the cities founded at its terminal points—New York and Montreal.

A still more direct route to the great lakes and the west opens from the Hudson, by the valley of its tributary, the Mohawk, which leads west to the lowlands around Lake Ontario. "Seen from the railway, which follows it, the valley appears to be a trench about 500 ft. deep, with moderately steep sides, and an average width of half a mile. Seen more truly from above the bordering uplands, it is a vast gap, 1,500 to 2,000 ft. deep, and several miles wide in its higher part," cut across the entire breadth of the plateau. The Mohawk valley, which commands the great route to the west, is followed by the New York Central Railway to Buffalo. "There is not a difficult grade or an embankment or a trestle of any importance between New York and Buffalo (490 miles), and with slight exception, this holds good from Buffalo to the Rockies. Two thousand miles of splendid country are made tributary to the harbour of New York through this river gateway."

Climate. In a continent nearly 4,000 miles long we have every kind of climate, from polar to tropical, modified by elevation and distance from the sea. If we look at a map of the January isotherms, these show the same southward sweep from west to east as in Europe. Thus a great part of the continent has frost for longer or shorter periods in winter, and the centre of the continent, in the latitude of Central Italy, is as cold as Iceland. South of 35° N., there are no winter frosts. Florida and California have a January like that of Egypt, and the tropical lowlands of Mexico have a January temperature of 70° F.

In summer the isotherms are bent north. Over most of the mainland the summer temperature is not below 50° F. The isotherm of 60° F., which crosses central England, traverses North America at the southern end of Hudson Bay, and runs north as we go west. The same regions which have very severe winters have thus warm summers. The isotherm of 70° F. strikes the west coast in about latitude 30° N., and runs almost due north for 20 degrees and then crosses the continent. South of latitude 30° the summers are hot, especially in the interior, where the lands in the lee of the Rockies are cut off from cooling ocean winds.

Rain falls abundantly on the Atlantic coast from Labrador southwards, and south of Newfoundland at all seasons. The rainfall diminishes slowly but steadily as we go west, and becomes extremely scanty west of the Mississippi, where the lands in the lee of the Rockies have a very dry climate. The west coast has abundant rain, especially in the north, where it falls at all seasons. Further south is California with winter rains, or a Mediterranean climate. In the trade wind area, the rainfall diminishes, and this explains why in the lee of the southern Rockies rainless deserts are found. If the continent were here broad like North Africa, instead of narrow, we should have a Sahara. As it is, we have desert resembling the Kalahari.

Vegetation. The vegetation of Arctic North America is of the familiar tundra type. Much of this region, especially round the northern part of Hudson Bay, has the expressive name of the Barren Grounds. Vegetation consists of moss and lichens, or of low berry-bearing bushes, with stunted trees in protected spots. To the south it passes gradually into poor woodland, the birch being found as far north as any of the conifers. In winter the tundra is frozen, and in spring, when the rivers are melting, it is flooded. Only in summer does it tempt north the caribou—the American reindeer. The caribou has never, like the reindeer, been domesticated, and there is consequently no summer migration of population north, as in the Old World. The Indian hunter, indeed, follows the trail of the caribou, but only for purposes of destruction. In the worst parts of the Arctic region, however, where vegetation practically ceases, we get the interesting Eskimo people, who live by slaying the creatures of the Polar Seas—bear, walrus, whale, etc., and show great ingenuity in supplying all their wants from these animals.

Forests and Steppes. Forests succeed the tundra, both in east and west. Thousands of square miles are covered with virgin forests, containing magnificent timber. This gives rise to the important industry of lumbering. When the forest streams are frozen in winter, the lumbermen start for the woods, where they remain for several weeks, felling trees and dragging them over the firm frozen ground to the banks of the streams. When these thaw in spring, the swollen current whirls along its burden of logs to one of the great timber or lumber centres, where innumerable saw mills, turned by the river, soon transform the lumber into timber, wood pulp, etc. Beyond the forests, in the dry centre of the continent, we find the dry steppes or grass lands, generally called the prairies. Where the rainfall is sufficient for cereals, wheat is grown in the north and maize further south. The dry western prairies are used for cattle breeding. Many thousands of acres go to form a cattle ranche, on which thousands of head of stock run in a semi-wild condition.

The belt of desert in North America is relatively small. Neither savanas nor tropical forests are found, except in parts of Mexico and Florida.

Occupations. Hunting is the only means of livelihood for the Eskimo of the Arctic Ocean, Hudson Bay, and Greenland. The trapping of fur animals is important on the tundra and forest margins. Large herds of buffalo once roamed the prairies, and were hunted by numerous Indian tribes, but the white man exterminated them with more than savage recklessness.

In the forests, lumbering is important, and supports such industries as saw-milling, pulping, paper-making, etc., in the towns on the forest margin. In the eastern prairies wheat is grown on a vast scale. Flour-milling is important in towns adjacent to the prairie wheat belt. Further west stock raising or ranching suits the drier climate better. It leads to an immense trade in meat and other animal products. All the western mountains are rich in minerals, and mining is important in many parts. The sea fisheries of both the east and west coast are very valuable, especially in Canada and Newfoundland. The northern rivers of the Pacific slope teem with salmon, which are canned in immense quantities.

The industries of the towns are very varied. Manufactures are carried on with cheap water power in many of those of the east, especially in the United States at the base of the Appalachian highlands and on the coalfields.

Races. The original Indian inhabitants are now comparatively few in number, and confined to the tundra, the forests, or their own reservations. The modern American is of European descent. Except in the lower St. Lawrence basin British blood predominates in Canada, as well as in the United States, though all European nations are well represented. Spanish blood is pre-eminent in Mexico, where Spanish is spoken, and the religion is Roman Catholic. The rest of the continent is English speaking and mainly Protestant. Negroes of African descent are numerous in the southern United States, and Chinese have settled on the Pacific coast.

CANADA

Let us look out in a map the frontiers of Canada, noticing that its boundary with the United States is quite artificial. Of its total area (3,460,000 sq. miles), large portions are of little value. Its natural advantages include (1) vast forests, supplying timber, an asset of ever increasing value ; (2) immense and fertile wheat lands ; (3) great mineral wealth, including the rich Klondike goldfields of the Rockies ; (4) valuable fisheries ; (5) an unrivalled series of natural waterways ; (6) a healthy, bracing climate, stimulating to exertion.

British Columbia. This, the Switzerland of Canada, is the largest province of the Dominion (383,000 sq. miles). It has an equable climate, with much rain in the west. Its mountain scenery is among the finest in the world. The mountains provide two valuable sources of wealth—minerals and timber. There are gold mines round Rossland, in the rich Kootenay district. Thick seams of fine steam coal occur near the Crow's Nest Pass, much of which is sent west to the Pacific ports, and east to the plains. Mining towns are continually springing

up in all directions. The rivers, which are navigable only for a short distance above their mouths, teem with salmon, the canning of which is a flourishing industry. The sea fisheries off the Pacific coast, whose fiords recall those of Norway, are also valuable. The most important city on the mainland is Vancouver, whence lines of steamers sail to China, Japan and Australia. The capital is Victoria, on Vancouver Island, near the naval station of Esquimalt. The Nanaimo coal mines in the vicinity are extremely important.

Arctic Canada. Round the Arctic Ocean and Hudson Bay lie the thinly-peopled districts of Yukon, Franklin, which includes the Arctic islands, Mackenzie, with its great lakes, Keewatin, the cold "land at the back of the north wind," and Ungava. The surface is tundra, or thin forest country, the home of many furbearing animals. Along the coast live a few Eskimos, but the bulk of the inhabitants are Indian hunters. A few white men are found at the trading posts scattered along the margin of the hunting grounds. Winter lasts several months, and then all travel is performed by dog teams or on snow-shoes. In summer, light bark canoes are used on the numerous rivers and lakes. There are no towns.

Saskatchewan and Alberta. These provinces are in process of settlement. Most of their surface is prairie land, though certain parts are wooded. In Eastern Saskatchewan are fertile wheat lands, the area of which is growing rapidly. In the drier districts of South-western Alberta ranching is important. Warm chinook winds descend from the Rockies and melt away the snow, so that stock can forage for themselves for a great part of the winter. These territories are rich in minerals. Coal is widely distributed in Alberta, and is mined for local consumption, helping to make up for the lack of timber. Petroleum is said to be abundant in the north. Towns are few as yet. Regina is the capital of Saskatchewan, and Calgary of Alberta. Medicine Hat, an important station on the Canadian Pacific line, is in a ranching district. Edmonton, in North Alberta, in an extensive agricultural district, is the largest fur market in North America. Lethbridge has large coal mines.

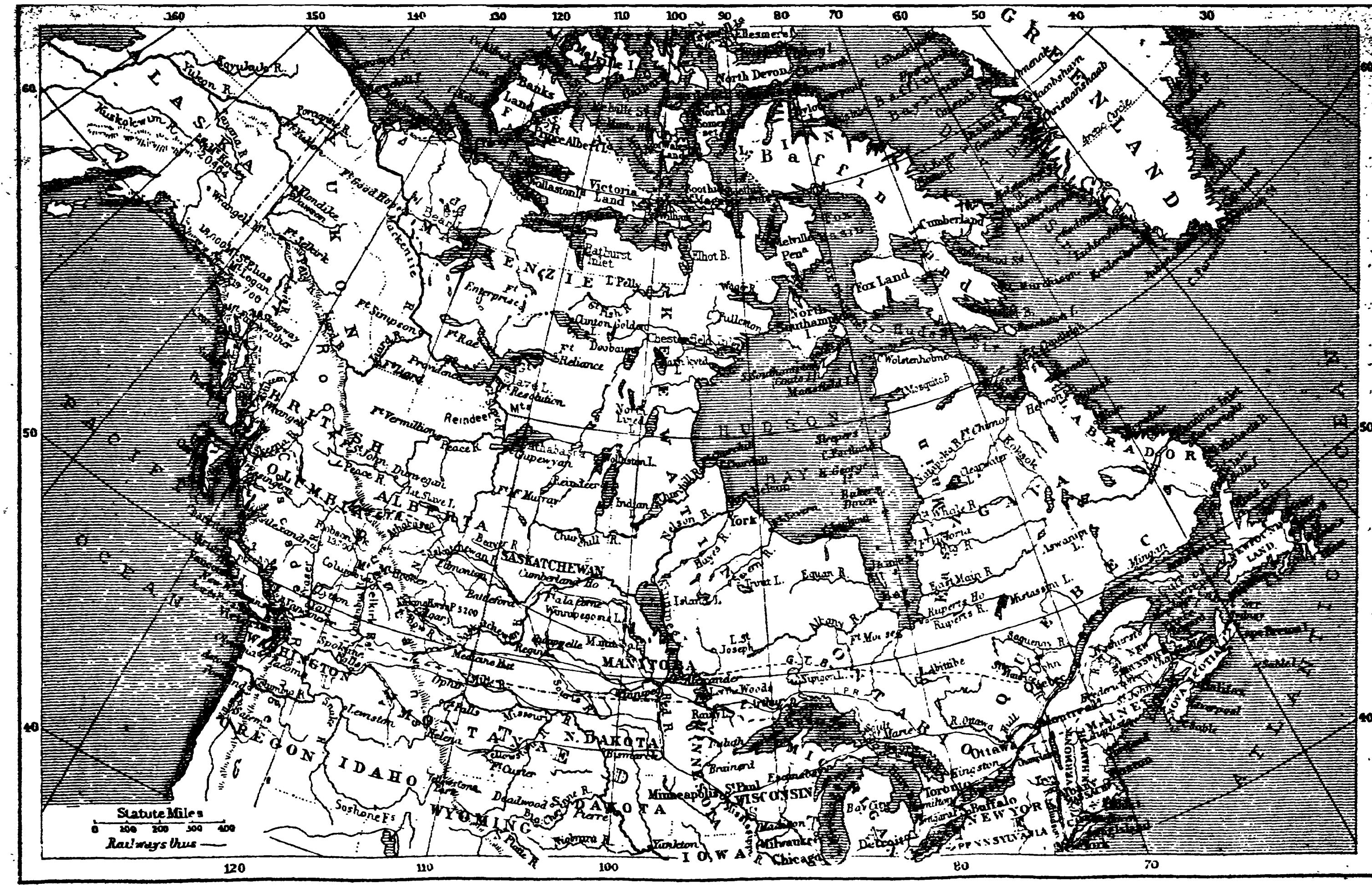
Manitoba. The lake province of Manitoba, in the centre of the continent, lies partly in the prairie wheat belt and partly in the forest country, where lumbering is important. In the agricultural districts wheat is the mainstay, but dairy farming and the fattening of hogs and stock are rapidly becoming important. "Formerly, if an early frost damaged a farmer's wheat, he sold it at about half price, and lost heavily. Now he feeds his hogs with it, and in the end the return is almost as great as it would have been from the uninjured wheat." Manitoba is thus at a higher stage than the provinces just described, where the prosperity of a whole district depends on a single staple. The capital is Winnipeg, a great railway centre, with excellent facilities for water communication in all directions. In autumn the railway traffic is enormous, as the whole wheat harvest of the prairies has to be forwarded to the eastern markets. Winnipeg has an important university, and is rapidly becoming the political, social, educational, and commercial capital of the west. The other considerable towns are Brandon, a wheat market, and Portage la Prairie, with flour mills.

Farming in the Great West. In the wheat-growing prairies ploughing begins in autumn, and goes on steadily till stopped by the frosts of November or December. In April, wheat is sown first, when the soil is still moist after the thaws. The early summer months may be spent in breaking up new fields in the virgin prairie, or in the care of dairy and other needful farm work. The hay harvest is carried in July, and if cattle are extensively kept, there will be a maize harvest to get in for winter fodder for the dairy cows. "As the wheat begins to head, the western farmer casts many an anxious glance at the weather, for occasionally a late frost comes and damages his crop. In August the wheat is ripe and the harvest begins. The grain is rapidly cut and bound by machines called binders. In the east it is stored in barns, to be threshed later, but in the west the crop is too heavy for this, so it is hauled to a stack, and piled ready for the threshers. Just before cutting, the western wheat fields present a lovely picture. As far as the eye can reach the grain waves and ripples in the warm summer breeze like a sea of gold."

As soon as the grain is cut and stacked comes the threshing. In the west, farms are far apart so a threshing gang travels with the threshing mill. The gang sleep in a large van. This is taken from place to place by the traction engine, which draws the threshing machine and supplies the driving power when the mill is at work. As the hum of the threshing mill begins, the scene is a lively one. Every man has his appointed place, and the stack of grain grows rapidly smaller as the pile of straw heaps up, and the sacks are filled with the bright clean grain. As soon as threshing is over the farmer hauls his grain to the nearest railway station, where it is sold and stored in the elevator ready for transport to the east over the Canadian Pacific Railway.

Ontario. Ontario (222,000 sq. miles), the richest province of Canada, larger than Germany, lies between the great lakes and James Bay, a gulf of Hudson Bay. The northern climate is dry, bracing and extreme; but the neighbourhood of the great lakes makes Southern Ontario moist and rather enervating. Ontario is a region of lower hills, lakes and rivers, many of which have falls. The north is densely forested, supplying valuable lumber. The Ottawa river brings down enormous quantities to be sawn in the innumerable saw mills turned by the Chaudière Falls. The southern part is cleared and dotted with towns and villages at short intervals.

The occupations of Ontario are numerous and varied. Lumbering in the backwoods makes saw milling, pulping, and other methods of working up timber important. Southern Ontario is a farmer's country. Unable to compete with



140. THE DOMINION OF CANADA

the wheat lands of the virgin west, farmers find dairy and mixed farming more profitable, and cheese and butter are produced in enormous quantities. The Lake peninsula, between Huron and Erie, is a land of orchards, where every kind of fruit is grown, especially peaches and grapes Wine is made in considerable quantities Special fruit trains run from this district in the season supplying cheap fruit to the large cities of Canada and the United States Round Lake Huron are deposits of salt and mineral oil Nickel is abundant round Sudbury, and copper north of Lake Superior Other minerals, including gold and iron are probably widely distributed though unworked

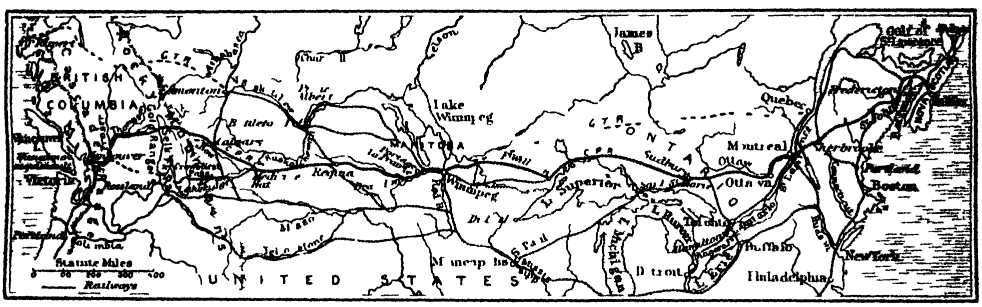
Industries. The fisheries of the great lakes employ large numbers of persons, and fish trains with refrigerating cars distribute the fish to inland centres

Manufactures, carried on by water or electric power, are developing, and include textiles, railway plant, brewing, distilling, etc Hamilton, on Lake Ontario, is a manufacturing centre

Toronto, the provincial capital, with a university, is a handsome town with a good harbour on Lake Ontario The Dominion capital supplied by the falls generates electricity for lighting Buffalo, in New York State, and for industrial purposes.

Towns. Quebec (347,000 sq. miles) was founded by French settlers, and many of the inhabitants are French speaking and of French descent The province, which is half as large again as Ontario, is densely forested, and lumbering is a leading industry Agriculture and fishing are also very important Minerals are abundant, except coal There is, however, ample water power, and manufactures will be carried on by electric power

The largest city is Montreal, with excellent communication by river, rail and canal. It is built at the foot of Mont Royal, and has many fine buildings The shores of the St Lawrence are lined for miles with wharves, from which are shipped the wheat, timber and dairy produce of the Dominion, and to which imports of all kinds are brought The manufactures of Montreal are growing rapidly Quebec, the capital, is one of the oldest cities in America. Its commanding situation on cliffs above the broad river makes it the Gibraltar of the St. Lawrence Hull, on the Ottawa opposite



141 THE CANADIAN PACIFIC RAILWAY

Ottawa, a great lumber centre is finely situated at the foot of the Chaudière Falls It is connected by the Rideau Canal with Lake Ontario

Ontario is well situated for commerce Railways run in all directions, and there are many excellent harbours on the lakes Canals have been cut to avoid the rapids between the lakes, the most important being the Soo, or Sault Ste Marie Canal, between Huron and Superior where an industrial town is growing up The tonnage which passes through the canals on the Canadian and United States sides of the rapids in spite of being frozen five months every year, exceeds that of the Suez Canal, so enormous is the volume of trade carried by this magnificent system of inland waterways

Niagara Falls. Lakes Erie and Ontario are connected by the short Niagara river, on which are the famous Niagara Falls The river is a mile wide where it makes its great leap sheer down 160 ft into the narrow boiling ravine below, down which its waters surge to Ontario. There are practically two distinct falls, separated by an island The fall on the Canadian side is the Horseshoe Fall, a little lower than the American fall. The power

Ottawa and Sherbrooke near Montreal are manufacturing towns

New Brunswick. The maritime province of New Brunswick (28 000 sq miles) has immense forests, which are often ravaged by disastrous fires Much lumber is cut in winter, floated down in spring, and sawn and worked up in summer Minerals are abundant, but hardly worked, the fisheries, however, are extremely valuable The south and east are settled, but the towns are small The capital is Fredericton, at the head of the tidal waters of the St John river, at the mouth of which is St John This port is never closed by ice, and in winter it is the shipping port of the Canadian Pacific Railway

Nova Scotia. Nova Scotia (20,600 sq. miles) consists of the Nova Scotia peninsula and Cape Breton Island It has high hills and broad valleys, with many lakes and rivers. The climate resembles that of England, but is more extreme Atlantic fogs are common. The coast islands are rocky and poor, but the western valleys of the interior are famous for their apple orchards. Much of the country is forested and lumbering is important. Shipbuilding

flourishing occupation before the days of iron and steel, has declined, but will develop as the coal-mines and ironworks around Sydney, on Cape Breton Island, increase their output. The fisheries are important. The capital is Halifax, with a magnificent ice-free harbour capable of holding the whole British Navy.

Cape Breton Island somewhat resembles Scotland. Its occupations are lumbering, fishing, mining and shipbuilding. Sydney is the chief town.

Prince Edward Island. This small island (2,000 sq. miles) owes much of its fertility to "mussel-mud," the decomposed remains of shell-fish, of which there are deposits many feet thick along the coast. The mud is raised by machinery and spread over the land, most of which is under cultivation. Dairy farming is important. Hay and potatoes are grown for the United States markets. The fisheries, especially of shell-fish, are very valuable. The capital is Charlottetown.

Newfoundland. Newfoundland (42,000 sq. miles) has been called the Norway of the New World. There is no little resemblance in the character of the island with its long fiords running inland between high walls of rock, but the mountains are very much lower. The chief occupation in both is fishing, supplemented by some farming. The Newfoundland fisheries are among the most valuable in the world. Three parts of the catch consist of cod, taken on the shores of Newfoundland itself, on the Great Banks a day's sail away, and off the desolate Labrador coast, which is included in Newfoundland. Many vessels go north annually to the seal fisheries.

Newfoundland is mountainous in the west, but flatter in the east. The interior is forested. Both lumbering and shipbuilding are important. Minerals, especially copper, are abundant; iron is exported to Canada from Bell Island. Dairy farming and agriculture are developing. The capital is St. John's.

Trans - Canadian Railways. The C.P.R., or Canadian Pacific Railway, crosses Canada from ocean to ocean. The Atlantic ports are Halifax and St. John, open all the year, and the summer ports of Quebec and Montreal. The Grand Trunk line is constructing a railway from Quebec to Port Rupert on the Pacific, north of the C.P.R., viâ Winnipeg and Edmonton. A network of lines covers the regions round the great lakes, and connects with the lines of the United States, that by the Hudson to New York being the most important.

The C.P.R. The trans-continental part of the C.P.R. begins at Fort William, on Lake Superior, whence the line runs west through a thinly forested region. About 50 miles from Winnipeg the country opens out into level prairie, covered over vast areas by wheatfields. At Winnipeg the sight of many miles of sidings and innumerable elevators brings home to the traveller the magnitude of the harvest of these vast plains. Beyond Medicine Hat the line follows the Saskatchewan valley, and reaches Alberta in the ranching country. The distant Rockies appear on the horizon, and the line soon enters the foot hills. The ascent is made by the Bow valley, amid glimpses of fine forest, mountain and glacier scenery, to the summit of the pass (5,000 ft.). The descent on the opposite side is by the precipitous Wapta valley. "The railway follows the river, crossing from side to side, and clinging to the ledges of dizzy precipices." In the first part of the descent there is a drop of 1,150 feet in five miles, and in the steepest parts the speed is reduced to five miles an hour. At last the cañon opens to the broad valley of the Columbia, with a fine prospect of the Rockies on the one hand, and the Selkirks on the other, with their steep forested slopes rising to the glaciers and snow-peaks beyond [141]

A Wonderful Climb. This range is next crossed by a triumph of engineering. The line turns up the narrow gorge of the Beaver, clinging to the sides of the mountains, and turning up side valleys till at last, between gigantic peaks, and in sight of imposing glaciers, the summit of the pass is reached (4,500 ft.). The descent to the valley of the Columbia, which has gone round the Selkirks while the line has crossed them, is made by the valley of the Illicillwaet, a descent almost as steep as that of the Wapta gorge. Those who have travelled in the Alps will form an idea of the skilful engineering devices employed—the winding tracks, the loops, and curves, used to reduce the sheerness of the descent. Often as many as four tracks, one below the other, are in sight at once. At last, however, the Columbia valley is reached, and the line is carried across the Gold range by a low pass, which runs for many miles between vertical cliffs. Four beautiful lakes occupy the whole width of the summit level, and the line proceeds west by the Shoushwap and Kamloop lakes, to plunge at last into the gloomy Thompson cañon, from which it emerges to follow the wild cañon of the Fraser.

"Through this gorge, so deep and narrow in places that the sun's rays hardly enter it, the black waters of the river force their way. We are in the heart of the Cascade range, and above the walls of the cañon we see mountain peaks gleaming against the sky. Hundreds of feet above the river is the railway, notched into the face of the cliff, and continually crossing some deep chasm by a great viaduct, or disappearing into a tunnel through some projecting spur." At last the cañon widens to a valley, meadows appear, farms and orchards vary the scene, and the sight of steamboats on the Fraser show that the great descent is over. The blue waters of the Pacific come in sight, and the train reaches Vancouver, the Pacific terminus.

Continued

ITALIAN—FRENCH—GERMAN—SPANISH

Italian by F. de Feo; French by L. A. Barbé, B.A.; German by P. G. Konody and Dr. Osten; Spanish by A. de Alberti and H. S. Duncan

ITALIAN

Continued from page 1 8

By Francesco de Feo

PERSONAL PRONOUNS—continued

Use of the Conjunctive Forms. The conjunctive forms of the personal pronouns may be combined together, and then the forms *mi, ti, si, ci, vi,* ', are changed into *me, te, se, ce, ve, glie,* when they occur with *lo, la, le, li, ne,* which they always precede *Glie* is always written in one word with *lo, la, le, li, ne,* and, in this case, it stands for *to him* as well as for *to her* Thus we have the following forms, which are placed before the verb

Mi, to me
me lo, me la, it, him, her to me
me li, me le, them to me
me ne, of it, of him, of them, etc, to me

Ti, to thee
te lo, te la, it, him, her to thee
te li, te le, them to thee
te ne, of it, of him, of them, etc, to thee

Si, to himself, etc
se lo, se la, it, him, her to himself, etc
se li, se le, them to himself, etc
se ne, of it, of him, etc, to himself, etc

Ci, to us
ce lo, ce la, it, him, her to us
ce li, ce le, them to us
ce ne, of it, of him, etc, to us

Vi, to you
ve lo, ve la, it, him, her to you
ve li, ve le, them to you
ve ne, of it, of him, of them etc, to you

Gli, to him, *le*, to her
glielo, gliela, it, him, her, to him or to her
glieli, gliele, them, to him or to her
gliene, of it, of him, of them, etc, to him to her

NOTE The forms *glielo, gliela glieli, gliele, gliene* are also used for it, him, her, them, of it, etc, to them, and, as we shall see later, to you Note here the forms *ci, vi*, there (*e g*, *ci sono*, there are, *vi sarà*, there will be), which in combination become *ce, ve*, with meanings that will be easily gathered from the following

ce lo troverete you will find him there
ce la troverete you will find her there
ce li troverete — you will find them there
ce ne troverete — you will find some there

EXAMPLES: 1 *Me lo promisero*, They promised it to me 2. *Me ne hanno parlato*, They have spoken to me of it 3. *Te li darò*, I shall give them to thee. 4 *Te la mostrerò*, I shall show her [omit] to thee 5. *Se li sono spesi*, They have spent them themselves. 6. *Ce ne presteranno*, They will lend us some. 7. *Ve lo proibisco*, I forbid it you. 8. *Glielo spiegheremo*, We shall explain it to him, etc 9. *Non gliene parlate*, Do not speak of it to him, etc 10. *Non ce n'è più*, There is no more of it

Position of the Conjunctive Forms. It has been seen that the conjunctive pronouns (*mi, ti, si*, etc) and their combined forms (*me lo, te lo*, etc) are, as a rule, placed before the verb. But when they occur with the *imperative* (the third persons excepted), the *infinitive*, the *gerund*, and the *past participle*, they are placed after the verb, and are written in one word with it. They are also joined in the same way to the word *ecco*, as *eccoli*, here they are; *eccoci*, here we are The infinitive drops the final *e* before the conjunctive forms, as *vendere*, to sell; *vènderlo*, to sell it, *vendergliela*, to sell it to him If the infinitive ends in *rre* the final *re* is dropped, as *indurre*, to induce, *indurci*, to induce us. When the infinitive is governed by another verb, the above forms may be placed before this verb, as *Non posso darvelo*, or *non ve lo posso dare*, I cannot give it to you But if the pronoun depends upon the first verb it must never be placed after the infinitive, as. *Vi làscio andare*, I let you go, and not *lasciovi andarvi* In the imperative negative it is better to let the pronoun precede, as *Non me ne parlate*, Do not speak of it to me

In poetry and in literary style the conjunctive pronouns may be added to other forms of the verb, besides those mentioned above, as. *rispòsegli*, he answered him When the verb ends in an accented vowel, the written accent is omitted and the conjunctive forms (*gli* excepted) double the initial consonant, as *dammi*, give me; *dicci*, tell us, *mostrerovvi*, I will show you; *dirogli*, I will tell him

NOTE *Loro* is generally placed after the verb, but is never joined to it: *L'ho mandato loro*, I have sent it to them

EXAMPLES 1 *Devo scrivergielo*, I must write it to him 2 *Che essi glielo restituiscano*, That they give it back to him 3 *Dàtemelo*, Give it to me 4 *Non glielo date*, Do not give it to him 5 *Avendomene parlato*, Having spoken to me of it 6 *Vedùtolo*, Having seen him 7 *Eccoci*, Here we are 8. *Eccolo lì*, There he is 9 *Non potete negarlo*, You cannot deny it 10. *Lo fècero arrestare*, They had him arrested

EXERCISE XXIX.

1 Avevamo pensato di vèndergli dei biglietti, ma non ne ha voluto comprare. 2. Me ne hanno mostrato di diverse qualità. 3. Se ne avessi ancòra, ve ne darei. 4. Dov'è vostra zia? 5. Eccola qui, parlàtegliene. 6. [illegible]

belli questi quadretti; se andate in Italia non dimenticate di compràrmene. 7. Ho comprato dei giocàttoli per questo ragazzino, ma ho dimenticato di portàrglieli. 8. Non glieli portate, perchè è stato cattivo tutto il giorno. 9. Se la sarta ha finito la mia veste, dìtele di mandàrmela sùbito. 10. Non mancherò di dìrglielo.

EXERCISE XXX.

1. Don't you see that this little girl's face is all dirty with smoke? Wash it for her. 2. If you have some fresh roses and carnations, make a nice bouquet of them, and send it to this address. 3. I had begged of you not to tell her anything, and you have told her everything. 4. Here is the letter that we have received, read it to her, and see what impression it makes on her. 5. If she had said such words to us, we should have known how to answer her fittingly (*per le rime*). 6. This telegram was handed to you at twenty past seven. How is it that you give it to me after more than two hours? 7. If you like to go to the theatre, go [there]; I prefer not to go out (*uscire*). 8. I will treat him as my brother, I promise [it] you. 9. Here is the telegram that we have received: "Received cycles; will send them you." 10. It is in Italian; I do not understand it; translate it for me, please.

CONVERSAZIONE

Se il signor N. domanda di me, ditegli che lo aspetto al circolo.

Glielo dirò.

Mandate a comprare delle sigarette e offrìtegliene.

Gliene abbiamo già offerto.

Perchè non me ne avete mai parlato prima? Avreste dovuto parlàrmene.

Me n'ero dimenticato.

Se non vi sarà possibile di venire, non dimenticate di avvertirci.

Certamente; vi manderò un telegramma.

Gli hai domandato di prestarti del danaro?

Gliel'ho domandato e me ne ha prestato.

Quando restituirete il danaro alla vostra amica?

Per il momento non ho danaro; ma appena ne avrò glielo restituirò.

Avete risposto alla lèttera di mio cugino?

Non ancòra; aspetto che il fotògrafo mi consegni le mie fotografie, perchè voglio spedìrgliene una.

VERBS—continued

The Passive Verb

As in English, the passive voice is formed in Italian by simply adding the past participle of an active verb to the various parts of the verb *èssere*: *egli è*, he is; *egli è amato*, he is loved; *egli sarà*, he will be; *egli sarà lodato*, he will be praised. The past participle after *èssere*, as we have already seen, must always agree in gender and number with the subject to which it refers: *egli è lodato, essa è lodata, i miei fratelli sono lodati, le mie sorelle sono lodate*.

The preposition *by*, which follows a passive verb, is translated *da*. She is loved *by* her brother, *Essa è amata da suo fratello*.

Essere amato, -*a*, -*i*, -*e*, to be loved

INDICATIVE MOOD

Present

I am loved, etc.	We are loved, etc.
Sono amato, -a, etc.	*Siamo amati, -e, etc.*

Past Indefinite

I have been loved, etc.	We have been loved, etc.
Sono stato, -a, amato, -a	*Siamo stati, -e, amati, -e*

Imperfect

I was loved	We were loved
Ero amato, -a	*Eravamo amati, -e*

First Pluperfect

I had been loved	We had been loved
Ero stato, -a, amato, -a	*Eravamo stati, -e, amati, -e*

Past Definite

I was loved	We were loved
Fui amato, -a	*Fummo amati, -e*

Second Pluperfect

I had been loved	We had been loved
Fui stato, -a, amato, -a	*Fummo stati, -e, amati, -e*

Future

I shall be loved	We shall be loved
Sarò amato, -a	*Saremo amati, -e*

Future Perfect

I shall have been loved	We shall have been loved
Sarò stato, -a, amato, -a	*Saremo stati, -e, amati, -e*

IMPERATIVE

Be loved	Be loved
Sia amato, -a	*Siate amati, -e*

SUBJUNCTIVE MOOD

Present

That I be loved	That we be loved
Sia amato, -a	*Siamo amati, -e*

Perfect

That I have been loved	That we have been loved
Sia stato, -a, amato, -a	*Siamo stati, -e, amati, -e*

Imperfect

If I were loved	If we were loved
Fossi amato, -a	*Fòssimo amati, -e*

Pluperfect

If I had been loved	If we had been loved
Fossi stato, -a, amato, -a	*Fòssimo stati, -e, amati, -e*

CONDITIONAL MOOD

Present

I should be loved	We should be loved
Sarei amato, -a	*Saremmo amati, -e*

Perfect

I should have been loved	We should have been loved
Sarei stato, -a, amato, -a	*Saremmo stati, -e, amati, -e*

INFINITIVE MOOD

Present—Essere amato, -a, -i, -e, to be loved

Perfect—Essere stato, -a, -i, -e, amato, -a, -i, -e, to have been loved

Gerund

Present—Essèndo amato, -a, -i, -e, being loved

Perfect—Essendo stato, -a, -i, -e amato, -a, -i -e, having been loved

OBSERVATIONS

1. In the Present, Imperfect, Past Indefinite, Future, and Conditional, instead of the verb *èssere*, may be used the corresponding tenses of the verb *venire* (to come), as: *vengo lodato*, I am praised; *vènnero trovati*, they were found. Occasionally the verbs *andare* (to go), and *stare* (to stay), are used in the same way, as: *andò perduto*, it was lost; *sta scritto*, it is written. *Andare* has sometimes the meaning of to be obliged to be, as: *Questo libro va custodito gelosamente*, This book must be carefully kept: *Questa parola va scritta così*, This word is to be written so.

2. The passive voice may also be formed by using the third persons (singular and plural) of the active verb preceded by *si*, as: *si dice*, it is said, they say, people say, etc; *si lèggono*, they are read, etc.

EXERCISE XXXI.

oràrio (*oràhreeo*), timetable	*calamite* (*cahlahmeètah*) magnet
ferrovia (*fehrroveèah*), railway	*fuoco* (*foo-òco*), fire
operaio (*opeh-ràh-eeo*), workman	*carbone* (*cahr-bòneh*), coal
schivare (*skee-vàhreh*), to avoid	*ladro* (*làhdro*), thief
ferito (*fehreèto*), wounded	*guerra* (*guèh-rrah*), war
avaro (*ahvàhro*), miser	*noioso* (*no-ee-òso*), tiresome

1. Quel ragazzo fu salvato per miràcolo. 2. Oggi è stato pubblicato il nuovo oràrio delle ferrovie. 3. Gli operai vèngono pagati ogni cinque giorni. 4. Fummo invitati, ma non ci andammo. 5. Egli è amato e stimato da tutti quelli che lo conòscono. 6. Mi dispiace di non potere accettare il vostro invito, perchè devo (I must) partire sùbito per Roma, dove sono stato chiamato telegraficamente. 7. È vietata l'affissione. 8. Si dice che la guerra fra i due paesi sia ormai inevitàbile. 9. Dìcono che il Generale N. sia stato ferito nell' ùltima battàglia. 10. Non èssere noioso, se no sarai schivato da tutti. 11. Questa storiella ci è stata raccontata da un nostro amico. 12. L'avaro viene attratto dall'oro, come il ferro dalla calamita. 13. Il fuoco è stato finalmente isolato; ma venti case e due depòsiti di carbone sono stati interamente distrutti. 14. Il ladro è stato arrestato.

KEY TO EXERCISE XXIX.

1. Speak more slowly, please, because I do not understand you. 2. Do not call him yet; let him finish writing. 3. Be silent; I forbid you to speak ill of a friend in my presence. 4. Which of these two do you prefer? 5. I prefer the first one, because it is cheaper. 6. If he asserts it, that means that it is true. 7. That poor child does nothing but cough all day. 8. Did you sleep well last night? 9. This tea is not good; you have poured the water on before it boiled. 10. Tell the servant to dress the children, because it is time to go. 11. If the artists sing well, we will applaud them. 12. This is already the third time that you ask me whether it is true: I must inform you that I never speak a falsehood. 13. Do not say so, please, because you have so many times told me falsehoods that I no longer believe anything that you say. 14. Eggs and meat are very nourishing. 15. I do not understand why you wish to be always right.

Continued

FRENCH Continued from page 3930 By Louis A. Barbé, B.A.

PRONOMINAL VERBS
General Remarks

1. Pronominal verbs are so called because they are conjugated with two personal pronouns which refer to the same person and of which one is the subject, the other the object of the verb, as *je me flatte*, I flatter myself.

2. The majority of pronominal verbs are reflexive—that is to say, they express an action of which the same person is both the "doer" and the "sufferer," as *il se blessera*, he will wound himself.

3. Pronominal verbs are either (*a*) essentially pronominal, or (*b*) accidentally pronominal. Essentially pronominal verbs are those that are never used otherwise than with two pronouns, such as *se repentir*, to repent; *s'emparer*, to seize, to get possession of; *s'abstenir*, to abstain.

Accidentally pronominal verbs are those which are sometimes conjugated with a single pronoun, that which represents the subject, and sometimes with two, thus: *il trompe*, he deceives; *il se trompe*, he is mistaken (lit., he deceives himself).

4. In the third person singular, and the third person plural, a noun may take the place of the subject; thus: *L'enfant se blessera*, The child will wound (hurt) himself; *L'armée s'empara de la ville*, The army took possession of the town.

4. The pronoun, which is the object of a pronominal verb is not necessarily a direct object, or accusative; it may also be an indirect object, or dative; thus: *Je me rappelle ce que vous m'avez dit*, I remember (lit., recall to myself) what you have told me. The use of the pronoun as an indirect object is particularly frequent when the direct object is a part of the body; thus: in *il se lave*, he washes himself, *se* is a direct object, whereas in *il se lave les mains*, he washes his hands (lit., he washes to himself the hands), *se* is an indirect object.

5. Pronominal verbs are reciprocal when they indicate an action which several subjects mutually do to each other, thus: *Nous nous voyons tous les jours*, We see each other every day. These verbs can only be used in the plural forms.

6. **When the reciprocity of the action expressed by the verb is quite clear, the pronominal form is sufficient, thus: *ils s'embrassèrent*, they embraced (each other).** If, however, it is not obvious whether the subjects do the action to each other or to themselves, reciprocity must be expressed by the addition of *l'un l'autre* (m.), *l'une l'autre* (f.), *les uns les autres* (m. pl.), *les unes les autres* (f. pl.), each other, or by the use of *mutuellement*, mutually, or *réciproquement*, reciprocally. Thus, *ils se flattent*, may mean either "they flatter themselves," or "they flatter each other." By saying *ils se flattent les uns les autres*, the latter meaning is made quite plain.

7. Pronominal verbs are very numerous in French. They are frequently used to express an action for which a simple verb is sufficient in English, as *se repentir*, to repent; *se lever*, to rise; *se coucher*, to lie down (go to bed); *se vanter*, to boast. A common use of the pronominal verb with reflexive meaning is to render the English passive voice, when that passive does not refer in a special manner either to the doer of the action or to the state resulting from that action. Thus: *Chaque volume se vend séparément*, Each volume is sold separately

8. All pronominal verbs form their compound tenses by means of the auxiliary *être*, to be. Thus: *Je me suis levé*, I got up; *Il s'était vanté*, He had boasted; *Tu te seras enrhumé*, You will have caught cold.

9. Although pronominal verbs take *être* in their compound tenses, the rule for the agreement of the past participle in those compound tenses is the same as if the auxiliary were *avoir*—that is to say, the past participle does not agree with the subject, but agrees with the direct object if that direct object precedes the past participle. Thus: *Nous nous sommes lavés*, We have washed, *lavés* agreeing with the *second* "nous," which is the direct object, and which precedes *lavés*. In *Elles se sont lavé les mains*, They (f.) have washed their hands, the direct object is not *se* (to themselves), but *les mains*, which comes after the verb. There is, consequently, no agreement of the past participle.

10. When given in the infinitive form (as in vocabularies, dictionaries, etc.), pronominal verbs are always accompanied by *se*, oneself, to oneself, as *se flatter*, to flatter oneself. In actual use, the infinitive may be preceded by *me*, *te*, *nous*, *vous*: *Je vais me promener*, I am going for a walk; *Il est temps de te lever*, It is time for you to get up; *Nous avions peur de nous tromper*, We were afraid of making a mistake; *Je vous prie de ne pas vous déranger*, I beg you will not put yourself out.

Se lever, to rise

Principal Parts: *se lever, se levant, s'étant levé, je me lève, je me levai.*

Indicative

Present	*Past Definite*
I rise, etc.	I rose, etc.
je me lève	*je me levai*
tu te lèves	*tu te levas*
il se lève	*il se leva*
elle se lève	*elle se leva*
nous nous levons	*nous nous levâmes*
vous vous levez	*vous vous levâtes*
ils se lèvent	*ils se levèrent*
elles se lèvent	*elles se levèrent*

Imperfect	*Future*
I was rising, etc.	I shall rise, etc.
je me levais	*je me lèverai*
tu te levais	*tu te lèveras*
il se levait	*il se lèvera*
elle se levait	*elle se lèvera*
nous nous levions	*nous nous lèverons*
vous vous leviez	*vous vous lèverez*
ils se levaient	*ils se lèveront*
elles se levaient	*elles se lèveront*

Compound Tenses.

Past Indefinite

I have risen, etc.	*nous nous sommes levés*
je me suis levé, or *levée*	or *levées*
tu t'es levé, or *levée*	*vous vous êtes levés*, or
il s'est levé	*levées*
elle s'est levée	*ils se sont levés*

elles se sont levées

Pluperfect

I had risen, etc.	*nous nous étions levés*,
je m'étais levé, or *levée*	or *levées*
tu t'étais levé, or *levée*	*vous vous étiez levés*, or
il s'était levé	*levées*
elle s'était levée	*ils s'étaient levés*

elles s'étaient levées

Past Anterior

I had risen, etc.	*nous nous fûmes levés*,
je me fus levé, or *levée*	or *levées*
tu te fus levé, or *levée*	*vous vous fûtes levés*, or
il se fut levé	*levées*
elle se fut levée	*ils se furent levés*

elles se furent levées

Future Anterior

I shall have risen, etc.	*nous nous serons levés*,
je me serai levé, or *levée*	or *levées*
tu te seras levé, or *levée*	*vous vous serez levés*, or
il se sera levé	*levées*
elle se sera levée	*ils se seront levés*

elles se seront levées

Conditional

Present

I should rise, etc.	*elle se lèverait*
je me lèverais	*nous nous lèverions*
tu te lèverais	*vous vous lèveriez*
il se lèverait	*ils se lèveraient*

elles se lèveraient

Past

I should have risen, etc.	*nous nous serions levés*,
je me serais levé, or *levée*	or *levées*
tu te serais levé, or *levée*	*vous vous seriez levés*, or
il se serait levé	*levées*
elle se serait levée	*ils se seraient levés*

elles se seraient levées

Imperative

Present

lève-toi, rise (thou)
qu'il se lève, let him rise
qu'elle se lève, let her rise
levons-nous, let us rise
levez-vous, rise ye
qu'ils se lèvent, let them (m.) rise
qu'elles se lèvent, let them (f.) rise

SUBJUNCTIVE

Present	*Imperfect*
That I may rise, etc.	That I might rise, etc.
que je me lève	*que je me levasse*
que tu te lèves	*que tu te levasses*
qu'il se lève	*qu'il se levât*
qu'elle se lève	*qu'elle se levât*
que nous nous levions	*que nous nous levassions*
que vous vous leviez	*que vous vous levassiez*
qu'ils se lèvent	*qu'ils se levassent*
qu'elles se lèvent	*qu'elles se levassent*

Past

That I may have risen, etc.
que je me sois levé, or *levée*
que tu te sois levé, or *levée*
qu'il se soit levé
qu'elle se soit levée
que nous nous soyons levés, or *levées*
que vous vous soyez levés, or *levées*
qu'ils se soient levés
qu'elles se soient levées

Pluperfect

That I might have risen, etc.
que je me fusse levé, or *levée*
que tu te fusses levé, or *levée*
qu'il se fût levé
qu'elle se fût levée
que nous nous fussions levés, or *levées*
que vous vous fussiez levés, or *levées*
qu'ils se fussent levés
qu'elles se fussent levées

INFINITIVE

Present	*Past*
se lever, to rise	*s'être levé, levée*, to have risen

PARTICIPLES

Present	*Past*
se levant, rising	*s'étant levé, levée, levés, levées*, having risen

Pronominal Verb Conjugated Negatively

Pronominal verbs are conjugated negatively:

1. In simple tenses, by putting *ne* between the two pronouns and *pas* after the verb.

2. In compound tenses, by putting *ne* between the two pronouns, and *pas* between the auxiliary and the past participle.

Ne pas se tromper, not to be mistaken

INDICATIVE

SIMPLE TENSES

Present

I am not mistaken, etc.
je ne me trompe pas, etc.

Imperfect

I was not mistaken, etc.
je ne me trompais pas, etc.

Past Definite

I was not mistaken, etc.
je ne me trompai pas, etc.

Future

I shall not be mistaken, etc.
je ne me tromperai pas, etc.

COMPOUND TENSES

Past Indefinite

I have not been mistaken, etc.
je ne me suis pas trompé, or *trompée*, etc.
nous ne nous sommes pas trompés, or *trompées*, etc.

Pluperfect

I had not been mistaken, etc.
je ne m'étais pas trompé, or *trompée*, etc.
nous ne nous étions pas trompés, or *trompées*, etc.

Future Anterior

I shall not have been mistaken, etc.
je ne me serai pas trompé, or *trompée*, etc.
nous ne nous serons pas trompés, or *trompées*, etc.

IMPERATIVE

Present

ne te trompe pas	*ne vous trompez pas*
be (thou) not mistaken	be (ye) not mistaken
qu'il ne se trompe pas	*qu'ils ne se trompent pas*
let him not be mistaken	let them (m.) not be mistaken
qu'elle ne se trompe pas	*qu'elles ne se trompent pas*
let her not be mistaken	let them (f.) not be mistaken
ne nous trompons pas	
let us not be mistaken	

SUBJUNCTIVE

Present

That I may not be mistaken, etc.
que je ne me trompe pas, etc.

Imperfect

That I might not be mistaken, etc.
que je ne me trompasse pas, etc.

Perfect

That I may not have been mistaken, etc.
que je ne me sois pas trompé, or *trompée*, etc.
que nous ne nous soyons pas trompés, or *trompées*, etc.

Pluperfect

That I might not have been mistaken, etc.
que je ne me fusse pas trompé, or *trompée*, etc.
que nous ne nous fussions pas trompés, or *trompées*, etc.

INFINITIVE

Present

ne pas se tromper, not to be mistaken

Past

ne pas s'être trompé, e, és, ées
not to have been mistaken

PARTICIPLES

Present

ne se trompant pas, not being mistaken

Past

ne s'étant pas trompé, e, és, ées
not having been mistaken.

KEY TO EXERCISE XXVII.

1. Nous recevons deux journaux tous les jours.
2. Elle reçoit ses amis le jeudi.
3. Nous aperçûmes une petite maison blanche au pied de la colline.
4. N'avez-vous pas encore reçu de réponse à votre lettre ?
5. Il est facile d'énoncer clairement ce que l'on conçoit bien.
6. Quand vous recevrez cette lettre je ne serai plus en Angleterre.
7. Vers dix heures du matin nous aperçûmes l'armée ennemie dans le lointain.

8. Il doit cinquante francs à son tailleur.

9. Si vous lui devez tant, ne me devez-vous rien ?

10. Vous devriez planter des arbres le long de cette allée.

11. Quand doit-il y avoir une assemblée des actionnaires ?

12. Si la bonne foi était exilée du reste de la terre, elle devrait se retrouver dans le cœur des rois.

13. Vous devriez d'abord me payer ce que vous me devez.

14. Elle a dû être bien étonnée de vous voir.

15. Vous auriez dû lui rendre l'argent qu'il vous a prêté.

16. Si vous n'avez rien mangé depuis ce matin, vous devez avoir bien faim.

17. Quelle heure est-il ? Il doit être au moins quatre heures et demie.

18. J'ai reçu une invitation, mais j'ai dû la refuser.

KEY TO EXERCISE XXVIII.

1. Entendez-vous ce que je vous dis ?

2. N'ayez pas peur du chien ; il ne vous mordra pas.

3. Vous perdez toujours quelque chose.

4. Pourquoi n'avez-vous pas répondu à sa lettre ?

5. Nous entendîmes du bruit en haut.

6. Qu'ils nous attendent maintenant, nous les avons attendus assez longtemps.

7. Attendez-les ; ils ne sont pas encore prêts.

8. Ne perdez pas tant de temps à bavarder.

9 Les ennemis, descendant de leurs montagnes, pillaient toute la contrée.

10. On vendra ces maisons aux enchères à onze heures précises.

11. Je fermai les yeux et j'entendis un fracas épouvantable.

12. Vous ne perdrez rien pour attendre.

13. La découverte de l'Amérique a beaucoup étendu le commerce européen.

14. Le Seigneur a étendu sa main sur la mer ; il a ébranlé les royaumes.

15. Le thermomètre a descendu de quatre degrés depuis hier.

16. Le jeune homme nous remercia sans embarras du service que nous lui rendions.

17. Rendez à César ce qui est à César, et rendez à Dieu ce qui est à Dieu.

18. Les coups que nous sentons le plus sont ceux que nous ne pouvons (pas) rendre.

19. Quelques grains rendent cent pour un, d'autres soixante, et d'autres trente.

20. Samson rompit ses cordes comme on romprait un fil.

21. À brebis tondue Dieu mesure le vent, dit le proverbe.

22. Ce chien est dangereux : il mord.

23. Il y a des personnes dont les louanges mordent et dont les caresses égratignent.

24. L'or fond à un moindre degré de chaleur que le fer.

Continued

GERMAN

By P. G. Konody and Dr. Osten

LXXXVIII. The Subject Clause. Wer gar zu viel bedenkt, wird wenig vollbringen, He who considers too much will achieve little. Here the subordinate clause replaces the subject and answers the question „wer (oder was) wird wenig vollbringen?" (Answer: Wer gar zu viel bedenkt, which is the subject of the compound sentence.)

The subordinate subject-clause is introduced by interrogative pronouns (ob, whether; wie, how; wann or wenn, when; wo, where; warum, why, etc.), or by relative pronouns (wer, who; was, what), or by the conjunction daß, that. Examples: Was nicht taugt, ist geschenkt zu teuer, What is useless, is too dear even as a present. Es ist erfreulich, daß die Sonne scheint, It is pleasing that the sun shines.

LXXXIX. The Object Clause. This, like the object it serves to replace, answers the question Wessen? whose? or Wem? to whom? or Wen oder Was? whom or what? It is introduced by an interrogative or by a relative pronoun. For the sake of greater clearness, a correlative demonstrative pronoun is often introduced into the principal sentence. Examples: Ich freue mich (wessen?) seiner Ankunft (object in the genitive), or, with a subordinate object clause: Ich freue mich, daß er angekommen ist, I am glad that he has arrived. Wen das Herz liebt, des (demonstrative pronoun) gedenkt es gern, Whom the heart loves it remembers gladly (proverbial sentence). Was geschehen muß, das (demonstrative pronoun) soll man nicht verschieben, What has to be done ought not to be postponed. If prepositions are needed, they are contracted with the demonstrative pronoun —an das into daran, von dem into davon, etc.: Was ein Geheimnis bleiben soll, davon (von dem) soll man nicht sprechen, What is to remain a secret should not be talked about.

XC. Contraction of Object Clauses. Object clauses introduced by the conjunction daß (*a*) can be contracted if the subject of the principal sentence is identical with that of the subordinate clause: Ich versprach ihm, daß ich gehen würde, I promised him that I should go; and Ich versprach ihm zu gehen. Contraction can also take place if the subject of the subordinate clause figures as object in the principal sentence, or if this relation is implied, though not actually expressed: Gott befahl den Menschen, daß sie (die Menschen) einander lieben, God commanded men that they should love each other, can thus be contracted into Gott befahl den Menschen einander zu lieben. As may be seen from the above examples, the contraction consists in the omission of the conjunction daß and of the subject in the subordinate clause, whilst the verb takes the prepositional infinitive with zu.

(*b*) In other cases the conjunction daß can be dropped, whilst the subordinate clause assumes the same sequence of words as an independent sentence, the subject preceding the predicate, etc.: Er erzählte uns, daß er das Feuer gesehen habe (dependent clause with finite verb at end), He told us that he had seen the fire; or, with the conjunction daß omitted: Er erzählte uns, er (subject) habe (predicate) das Feuer (object) gesehen, He told us he had seen the fire. Ich erinnere mich, daß ich das Feuer gesehen habe, I remember that I have seen the fire, is, on the other hand, contracted into: Ich erinnere mich, das Feuer gesehen zu haben, the subject being the same in the principal sentence and in the dependent clause.

(*c*) In some interpolated subordinate object clauses introduced by wie, as, this conjunction can be dropped, and the clause assumes the same sequence of words as the independent sentence of question (the verb preceding the subject): Er hat, wie er uns erzählte, das Feuer gesehen, He has, as he told us, seen the fire, or contracted: Er hat, erzählte er uns, das Feuer gesehen.

(*d*) In conditional clauses the conjunctions wenn, falls, if, can be dropped, in which case the clause is arranged as in (*c*): Wenn du nicht gehen willst, so bleibe daheim, If you don't want to go, stay at home; or, with omission of the conjunction wenn: Willst du nicht gehen, so bleibe daheim.

(*e*) With verbs with separable prefixes the preposition zu is inserted between the prefix and the stem: fort-gehen, to go away; Ich befahl ihm, daß er fortgehe, or contracted: Ich befahl ihm fort zu gehen, I bade him go away; but entfernen (inseparable prefix ent-): Ich befahl ihm, daß er sich entferne, or: Ich befahl ihm, sich zu entfernen.

XCI. The Subjunctive in Subordinate Clauses. In subject and object clauses the subjunctive is employed if the person speaking wishes to suggest that the context of the subordinate clause is merely an opinion of the "subject" in the principal sentence, or if something is expressed (wish, demand, hope, command, etc.) that has not yet been performed and has yet to become a reality: Ich glaubte, daß er angekommen sei, I thought that he had arrived; or, with the omission of the conjunction: Ich glaubte, er sei angekommen. For further rules as to the use of the subjunctive see LXVIII., page 3502.

NARRATIVE CLAUSES. The object clauses include those in which the speech of other persons is related, either directly (direct speech) or by circumlocution (indirect speech). The quotation, with the subjunctive of the verb, is frequently introduced by the conjunction daß; and the indirect clause of question by ob, whether, unless there is already a conjunction of question: Er fragte mich, ob ich kommen würde, He asked me whether I should come; and: Er fragte mich, wann ich kommen würde, He asked me when I should come.

EXAMINATION PAPER XXII.

1. Which cases are ruled by adjectives in German?
2. How many adjectives govern two alternative cases, and which are these cases? Enumerate the adjectives.
3. What prefix expresses the negative meaning of adjectives?
4. What is the difference between co-ordinate and subordinate clauses in a compound sentence?
5. What is the characteristic feature of the subordinate clause with regard to the verb?
6. What are the positions of the subordinate clause in a compound sentence?
7. How does the use of different classes of conjunctions affect the mutual relation of co-ordinate clauses?
8. Why is it often necessary to employ subordinate clauses, and when are they to be avoided?
9. How can the subordinate clauses be classified?
10. What is a subject clause, and by what words is it introduced?
11. What question (with regard to the case) is answered by the object clause?
12. By what words is the object clause introduced?
13. Which correlative pronouns are sometimes introduced into the principal sentence, and for what reasons?
14. When can a subordinate clause be contracted?
15. How does contraction by omission of certain words affect the verb in the subordinate clause?
16. What is the sequence of words in a contracted interpolated subordinate clause?
17. What considerations necessitate the use of the subjunctive in subordinate clauses?
18. By which conjunction are "narrative clauses" frequently introduced?

EXERCISE. Contract the following sentences:

Dem Kinde wurde befohlen, daß es im Zimmer bleibe.
The child was bid to stay in the room.
Dem Kinde wurde befohlen, daß es dableibe.
The child was bid to stay here.
Ich bat ihn, daß er mir helfe.
I begged him to help me.
Ich bat ihn, daß er mir mit einigem Gelde aushelfe.
I begged him to assist me with some money.
Ich bat ihn, daß er sich einstweilen ohne mich behelfe.
I begged him to get on meanwhile without me.
Er erklärte, daß er nichts davon wisse (Two variations possible). Der
He declared that he knew nothing about it. The

Vater fürchtete, daß ihm sein Sohn nichts mitteilen würde.
father feared that his son would tell him nothing.
Ich hoffe, daß ich morgen früh abreisen werde. (Two forms, as above.)
I hope that I shall start to-morrow morning.
Es war, wie er mir sagte, schrecklich. Der König wurde,
It was, as he told me, terrible. As the paper
wie die Zeitung berichtete, glänzend empfangen.
reported, the king was given a splendid reception.
Den Truppen wurde der Befehl erteilt, daß sie das Feuer
The troops were given the order to open
eröffnen. Gestatten Sie mir, daß ich Ihnen alles erzähle.
fire. Allow me to tell you all.
Erlauben Sie mir, daß ich Sie nächstens besuche. Ge-
Allow me to call on you shortly. Cer-
wiß, aber trachten Sie, daß Sie nicht den Zug versäumen.
tainly, but try not to miss your train.
Wenn es sich so verhält, dann bleibe ich noch. Falls
If this is the case, I shall stay yet [a while]. If
Sie es nicht wünschen, so wird es einfach nicht geschehen.
you do not wish it, it will simply not be done.

Key to Exercise in Examination Paper XXI.
(Page 3932)

Ich war meiner Pflicht eingedenk. Der Sohn ist seinem Vater ähnlich. Die Lüge war den Athenern angeboren. Die Sache schien dem Beamten bedenklich. Er hielt ihn eines solchen schrecklichen Verbrechens fähig. Der Gefangene war des Urteils gewärtig. Die Eltern sind der Sprache nicht mächtig. Die Soldaten waren des Dienstes überdrüssig. Den Soldaten war der Dienst überdrüssig. Das Kind ist seinen Eltern Gehorsam schuldig. Diese Handlung ist deiner unwürdig. Man überhob mich der Mühe. Die Verfolger wurden des Diebes habhaft. Dieser Zwischenfall erwies sich mir günstig. Das ist ihr ganz gleichgültig. Das Volk ist dem König untertan. Trotzdem der Fall dem Richter unklar war, fand er ihn des Verbrechens schuldig. Der Feldherr war dieser großen Überzahl nicht gewachsen, und ergab sich, als er der heranrückenden frischen Truppen ansichtig wurde.

VII. At the Theatre

What piece is played to-night at your theatre? Wagner's "Tannhäuser."	Was für ein Stück wird heute in Ihrem Theater gespielt? Wagner's „Tannhäuser".
Can I have a ticket?	Kann ich ein Billet haben?
Yes, but the only vacant seats are in the last rows of the stalls.	Ja, aber es sind nur Sitze in den letzten Reihen des Parketts frei.
There are no more seats in the front rows?	In den vorderen Reihen gibt es keine Sitze mehr?
Can you see well from the back rows?	Sieht man gut in den rückwärtigen Reihen?
Oh, yes; the theatre is built like an amphitheatre.	O ja, das Theater ist amphitheatralisch gebaut.
Can I have a corner seat?	Kann ich einen Ecksitz haben?
No, I am sorry, only the centre seats are vacant.	Leider nicht, nur in der Mitte sind welche frei.
How much is the seat? Four marks.	Was kostet der Sitz? Vier Mark.
When does the performance begin?	Wann beginnt die Vorstellung?
At 7.30 p.m.	Um halb acht Uhr Abends.
And when is it over? At 10.30.	Und wann endet sie? Um halb elf Uhr.
Is the cast good?	Ist die Besetzung gut?
The cast is excellent.	Die Besetzung ist vorzüglich.
Can I have a programme?	Kann ich einen Theaterzettel haben?
You will get that at the theatre.	Den bekommen Sie im Theater.
Is it also possible to get a book of the words?	Ist da auch ein Textbuch erhältlich?
Yes, you only have to ask at the box-office.	Ja, das bitte nur vom Billetteur zu verlangen.
Are there no automatic machines for opera glasses?	Gibt es keine Opernglas Automaten?
No, they have not been introduced here.	Nein, das ist bei uns nicht eingeführt.
How many minutes is the long interval?	Wie viele Minuten dauert die große Zwischenpause?
Where is the buffet? On the second floor.	Wo ist das Buffet? Im zweiten Stockwerke.
Is smoking permitted in the passages?	Darf man in den Couloirs rauchen?
Oh, no; it is not allowed anywhere within the theatre.	O nein, das ist in keinem Raume innerhalb des Theaters gestattet
Must one's stick be left in the cloak-room?	Muß man den Stock in der Garderobe abgeben?
Will you give me my overcoat?	Wollen Sie mir meinen Überrock geben?
Will you, please, get me a cab after the theatre.	Bitte, besorgen Sie mir eine Droschke nach dem Theater.

VIII. At the Barber's

I want a shave. Will you sit down, please.	Wollen Sie mich rasiren? Bitte Platz zu nehmen.
Will you soap me well, as my beard is stiff.	Bitte mich gut einzuseifen, da mein Bart hart ist.
Is the brush well cleaned?	Ist der Pinsel gut gereinigt?
We always clean everything most carefully after use.	Bei uns wird alles nach jedesmaliger Benützung auf das Sorgfältigste rein gemacht.
The razor is scraping a bit. Could you not sharpen it a little?	Das Rasirmesser kratzt ein wenig. Könnten Sie es nicht schärfer machen?
It is better now.	Jetzt ist es besser.
After washing, you can give me some eau de Cologne. And now a little rice powder.	Nach dem Waschen können Sie mir etwas Kölnisch Wasser geben. Und nun etwas Poudre de Riz.
Will you cut my hair, but not too short.	Bitte mir die Haare zu schneiden, aber nicht zu kurz.
I also want a shampoo.	Sie können mir auch den Kopf waschen.
How much do I owe you?	Was bin ich schuldig? or Was habe ich zu bezahlen?
Altogether it amounts to 60 pfennigs.	Alles zusammen macht 60 Pfennige.

Continued

SPANISH

Continued from page 3866

By Amalia de Alberti & H. S. Duncan

REGULAR VERBS—continued

Third Conjugation

Model Verb—**Vivir,** to live

INFINITIVE	GERUND
vivir, to live	*viviendo*, living

PAST PARTICIPLE

vivido, lived

INDICATIVE MOOD

Present	*Imperfect*
vivo, I live	*vivía*, I was living
vives, thou livest	*vivías*, thou wast living
vive, he lives	*vivía*, he was living
vivimos, we live	*vivíamos*, we were living
vivís, you live	*vivíais*, you were living
viven, they live	*vivían*, they were living

Past Definite	*Future*
viví, I lived	*viviré*, I shall live
viviste, thou livedst	*vivirás*, thou wilt live
vivió, he lived	*vivirá*, he will live
vivímos, we lived	*vivirémos*, we shall live
vivísteis, you lived	*viviréis*, you will live
vivieron, they lived	*vivirán*, they will live

CONDITIONAL MOOD

viviría, I should live
vivirías, thou wouldst live
viviría, he would live
viviríamos, we should live
viviríais, you would live
vivirían, they would live

IMPERATIVE MOOD

—	*vivamos*, let us live
vive, live (thou)	*vivid*, live (ye)
viva, let him live	*vivan*, let them live

SUBJUNCTIVE MOOD

Present

viva, I may live	*vivamos*, we may live
vivas, thou mayst live	*viváis*, you may live
viva, he may live	*vivan*, they may live

IMPERFECT

viviera, or *viviese*, I might live
vivieras, or *vivieses*, thou mightst live
viviera, or *viviese*, he might live
viviéramos, or *viviésemos*, we might live
vivierais, or *vivieseis*, you might live
vivieran, or *viviesen*, they might live

Future

viviere, when I shall live
vivieres, when thou wilt live
viviere, when he will live
viviéremos, when we shall live
viviereis, you will live
vivieren, they will live

NOTE. The compound tenses are formed with the verb *haber* and the participle *vivido*. Example: *he vivido*, I have lived, etc. Only the second person singular and plural are original forms, the rest are all borrowed from the subjunctive present. The original imperatives cannot be used in the negative; the negative imperative must be rendered by the subjunctive present.

ORIGINAL IMPERATIVES	NEGATIVE IMPERATIVES
ama, love (thou)	*no ames*, do not love
amad, love (you)	*no améis*, do not love
come, eat (thou)	*no comas*, do not eat
comed, eat (you)	*no comáis*, do not eat
vive, live (thou)	*no vivas*, do not live
vivid, live (you)	*no viváis*, do not live

The other persons being already in the subjunctive, need only the addition of *no* to become negative.

amemos, let us love   *no amemos*, let us not love

Euphonic Changes. The following changes are made in the spelling of certain regular verbs in order to retain the same pronunciation of the stem throughout the conjugation.

1. All verbs ending in *car* change the *c* into *qu* before *e*—that is, in the first person singular of the past definite, throughout the subjunctive, and in those persons of the imperative which are borrowed from the subjunctive. Example:

Tocar, to touch

Past Def.—*toqué, tocaste, tocó*, etc.
Sub. Pres. *toque, toques, toque, toquémos, toquéis, toquen.*
Imp. *toca, toque, toquémos, tocad, toquen.*

2. All verbs ending in *gar* take *u* after the *g* in the same persons. Example:

Pagar, to pay

Past Def.—*pagué, pagaste, pagó*, etc.
Sub. Pres. *pague, pagues, pague, paguémos, pagueis, paguen.*
Imp. *paga, pague, paguémos, pagad, paguen.*

3. All verbs ending in *zar* change the *z* into *c* in the same places. Example:

Alcanzar, to reach

Past Def.—*alcancé, alcanzaste, alcanzó*, etc.
Sub. Pres. *alcance, alcances, alcance, alcancémos, alcancéis, alcancen.*
Imp.—*Alcanza, alcance, alcancémos, alcanzad, alcancen.*

4. Verbs ending in *guar* take the diæresis in the same tenses—that is, before *e*. Example:

Averiguar, to ascertain

Past Def.—*averigüé, averiguaste, averiguó*, etc.
Sub. Pres.—*averigüe, averigüeis, averigüe*, etc.
Imp.—*averigua, averigüe, averigüemos, averiguad, averigüen.*

5. Verbs ending in *cer* and *cir* preceded by a consonant change *c* into *z* before *a* or *o*; that is, in the first person singular of the indicative present, throughout the subjunctive present, and in imperatives borrowed from the subjunctive. When the ending *cer* and *cir* is preceded by a vowel *z* is inserted before *c* whenever the latter is followed by *a* or *o*—that is, in the aforesaid places. Example:

Vencer, to vanquish

Ind. Pres.—*venzo, vences, vence*, etc.
Sub. Pres.—*venza, venzas, venza*, etc.
Imp.—*vence, venza, venzámos, venced, venzan.*

Esparcir, to scatter

Ind. Pres.—*esparzo, esparces, esparce,* etc.

Sub. Pres.—*esparza, esparzas, esparza,* etc.

Imp.—*esparce, esparza, esparzámos, esparcid, esparzan.*

Nacer, to be born

Ind. Pres.—*nazco, naces, nace,* etc.

Sub. Pres.—*nazca, nazcas, nazca,* etc.

Imp.—*nace, nazca, nazcamos, naced, nazcan.*

6. Verbs ending in *ger* and *gir* change *g* into *j* before *a* and *o*. Example:

Coger, to gather

Ind. Pres.—*cojo, coges, coge,* etc.

Sub. Pres.—*coja, cojas, coja, cojamos, cojais, cojan.*

Imp.—*coge, coja, cojamos, coged, cojan.*

Dirigir, to direct

Ind. Pres.—*dirijo, diriges, dirige,* etc.

Sub. Pres.—*dirija, dirijas, dirijamos, dirijais, dirijan.*

Imp.—*dirige, dirija, dirijamos, dirigid, dirijan.*

7. Verbs ending in *guir* drop the *u* before *a* and *o*. Example:

Distinguir, to distinguish

Ind. Pres.—*distingo, distingues, distingue,* etc.

Sub. Pres.—*distinga, distingas, distinga,* etc.

Imp.—*distingue, distinga, distingamos, distinguid, distingan.*

8. Verbs with stems ending in *ch, ll,* or *ñ*, drop the *i* in the diphthongs *ie, io* whenever these occur in the terminations—that is, in the gerund, third person singular and plural of the past definite, and in the imperfect and future of the subjunctive. Example:

Bullir, to boil. Gerund, *bullendo,* etc.

Plañir, to lament. Gerund, *plañendo,* etc.

Henchir, to fill. Gerund, *hinchendo* (irreg.), etc.

Vocabulary	Vocabulario	Vocabulary	Vocabulario
Adhere	Adherir	The vineyard	El viñedo
To confer	Conferir	A cart	
To consent	Consentir	A wheel	Una rueda
To convert	Convertir	The axle-tree	El eje
To give the lie	Desmentir	The yoke	El yugo
To amuse oneself	Divertirse	The whip	El latigo
		A reaper	Un segador
To wound	Herir	A carman	Un carretero
To infer, to deduce	Inferi	A vintager	Un vendidor
To invert	Invertir	(wooden) shovel	Una pala
To lie	Mentir		
To pervert	Perverti	A furrow	Un surco
To speak, to express	Proferir	A scythe	Una guadana
		A threshing floor	Una era
A quack	Un empirico		
A table	Una fabula	An arbour, or bower	Una enramada
A fatalist	Un fatalista		
Womanly	Femenil	A fountain	Una fuente
The fair	La féria	A tube-pipe	Un cano
The railroad	El ferrocarril	Potatoes	Patatas
Thin	Flaco	Artichokes	Alcachofas
Frivolous	Frivolo	Straw	Paja
The smoking-room	El salon para fumar	The aviary	La pajarera
		A bird-catcher	Un cazador de pajaros
The fugitive	El fugitivo		
The foundry	La fundición	The grain	El grano
Gallantly	Galantemente	The granary	El granero
The gallery	La galeria	The globe	El globo
The gallop	El galope	The glory	La gloria
The picklock	La ganzua	Heaven	El cielo, el firmamento
A brick	Un ladrillo		
A slate	Una pizarra	A glossary	Un glosario
A wood	Un bosque	A glutton	Un gloton
A desert	Un desierto	Syrup	Jarabe
(The) manure	El estiercol	A jug	Un jarro, jarra
A root	Una raiz	A cage	Una jaula
Vegetables	Las legumbres	A pack of hounds	Una jauria
A bunch	Un racimo		
The vintage	La vendimia	The chief	El jefe

Exercise XIII (1)

Translate the following into Spanish:

1. Since when has the banker M . . . . had the cross of . . . . ? 2. It was conferred on him after the war. 3. I shall be pleased to deny the false rumours which have been current in the town. 4. He was wounded in the right arm by a pistol shot. 5. Was it the right or the left ? 6. I have already said it was the right. 7. I inferred that he was ill. I have not seen him for many days. 8. That man is capable of perverting the wisest person, his doctrines are scandalous. 9. Let us go (vamos) to the fair, we shall certainly be able (podrémos) to buy good colts and horses. 10. The smoking-room is at the end of the garden. 11. To-morrow we will go (irémos) to the cannon foundry. 12. The thief opened the door with a picklock. 13. The sentinel is in the sentry-box. 14. Have you sufficient grapes for the vintage ? No, I have not sufficient ; but I have beautiful bunches. 15. Have you a vine ? I have two—one in Moguer, the other in Jeres 16. The axle broke when the horses were galloping (iban al galópe) and the carriage upset. 17. Death is represented with a scythe and hour-glass. 18. The reapers hold the superstition that if they cut any animal in reaping, whether bird, rabbit, or any living thing whatever, they have cut their own lives. 19. After the harvest is finished, the harvesters dance on the threshing floor ; it is a custom which dates from the Middle Ages. 20. The fountain in the garden is of marble, and the water very limpid.

Exercise XIII (2)

Translate the following into English :

1. Vengo para averiguar los pormenores del robo que tuvo (took) lugar ayer. 2. Nada mas podemos decir, á lo ya expuesto. 3. Sería posible coger á los ladrones si nos diéramos prisa. 4. No vale la pena, lo que cojieron es de poco valor, y despues de todo aquello de " vivir y dejar vivir " viene bien aqui. 5. Es hombre de gran voluntad, nació de la nada, y vea la posicion que ocupa ; piense en todas las dificultades que ha tenido que vencer. 6. Es muy distinguido. 7. Vamos á coger el tren. Es tarde y si no llegarán Vds á tiempo ; no lo cogerán. 8. ¡ Ten cuidado ! esparces esa semilla en el camino, y si no quedará ninguna para el jardin. 9. Esa mujer es muy frivola y superficial. 10. Fuimos anoche á la galería del Teatro Real, no me gustó la tragédia, la primera dama es demasiado vieja, y el primer galan no sabe declamar.

PROSE EXTRACT XI.

From a satirical essay by Antonio de Valbuena, entitled :

" Academicalities."	" Academiquerías."
You are all aware that the worst writer in Spain is the Academy, the Royal* Spanish Academy, whose office, according to itself, is	**Ya saben ustedes que quien peor escribe en España es la Academia, la Real Academia Española, encargada, según ella dice, de**

to purify, define, and add lustre to our native tongue. But though you have known this for a long time, it will be as well to remind you of it, in case you should forget it.

limpiar, fijar y dar lustre al idioma patrio. Pero aunque lo saben ustedes hace ya mucho tiempo, no será malo recordárselo para que no se les olvide.

It will also be as well to warn you, in order to spare you a shock, that the document we are about to examine emanates from the aforesaid Academy. Because it is the report of a solemn academical function, and it is a well-known fact that the Academy does not trust anyone with the task of singing its glories, but always does it itself. And it does well, because if it did not sing them, nobody else would.

Y tampoco será malo advertir á ustedes para evitarles algún susto, que el escrito que vamos á examinar ahora pertenece á la Academia referida. Como que es la reseña de un acto Académico solemne, y es cosa bien averiguada que la Academia no fia á nadie el encargo de cantar sus glorias, sino que lo hace por sí misma. Y hace bien, porque si no las cantara ella, no las cantaría nadie.

The Academy understands this, and therefore it is well known that after a session one of the Academicians present writes the eulogistic broadsheet to be sent to "La Correspondencia" and other newspapers having a large circulation. He reads it aloud, and after a few corrections, which make it, if possible, worse than before, it is approved, and sent to the editors with the trade-mark of the firm.

Así lo entiénde la Academia, y por eso ya se sabe, al concluirse cualquiera sesión, uno de los Académicos asistentes á ella escribe el suelto laudatorio para enviarlo á "La Correspondencia," y demás periódicos de gran circulacíon, le lee en voz alta, se aprueba después de alguna enmienda que lo empeore algo si es posible, y se remite á las redacciones con el sello de la casa.

The broadsheet, or rather the short article in question—for it is almost an article—appeared with two headlines. The first says: "In the Spanish Academy," and the one below, "Rewards of Virtue." Then it begins:

El suelto, ó más bien el articulejo de referencia, porque es casi un artículo, salió con dos rótulos. El primer dice: "En la Academia Española," y el que está debajo: "Premios á la virtud." Y empieza:

"Yesterday the Spanish Academy held a solemn public session in order to distribute the prizes awarded by the St. Gaspar Fund, which is governed by that learned body."

"Ayer celebró la Academia Española sesion solomne y pública para repartir los premios de la Fundación denominada de San Gaspar, que está regida, por aquella docta corporación."

Here we have the trade mark of the firm, which I mentioned a little while ago. For now no one alludes to the Academy as a "learned body," except the Academy itself, or some aspirant.

Aqui está el sello de la casa, de que hablé hace poco. Por que nadie llama ya *docta corporácion* á la Academia, mas que la Academia misma ó algún aspirante.

Therefore, the authenticity of the document is beyond dispute.

De modo que no cabe duda de la autenticidad del escrito.

Antonio de Valbuena (1844), a leading journalist, well known for literary and political satires. The above extract is a good example of light journalistic Spanish.

Antonio de Valbuena (1844), uno de los primeros periodistas bien conocido por sus sátiras literarias y políticas. El extracto que mas arriba citamos es un buen ejemplo del estilo ligero de los periódicos Españoles

Key to Exercise XII (1)

1. Compro la carne, los huevos y la leche en la hacienda; el hortelano es muy honrado.
2. Los compraré tambien ahí, tambien compraremos pollos, mi hija y yó.
3. ¿ Comen Vds muchas aves ?
4. Sí, nos gustan mucho.
5. Yó cómo mucha ave, hemos comprado perdices y faisanes.
6. Deseo demostrar á Vd este problema.
7. El juez ha fallado el pleito.
8. La fama de Shakespeare ha llegado hasta el fin del mundo.
9. Esa mujer amiga de Vd es capaz de embrollar á la familia más unida.
10. El carruaje, yendo por el camino real, volcó y el cochero y los caballos fueron lastimados.
11. Con prisa lleváron al prisionero á la cárcel.
12. Quizá venga á verme el medico, mi hijo se queja de dolor de cabeza.
13. Abra Vd su sombrilla, que el sol quema.
14. Cuando escaváron en la barranca encontraron una hermosa estátua.
15. El faro del puerto de Cádiz se vé de muy léjos.
16. Me han robado mi dinero del bolsillo.
17. ¿ Cuando fué esto ?
18. Cuando fuí á comprar la Biblia para los niños.
19. Deseo à Vd un feliz año nuevo.

Key to Exercise XII (2)

1. The orphans loved their father.
2. The students love their dog.
3. I shall love my children.
4. Do not fail to love thine enemy; thus the gospel commands.
5. Dine with us.
6. We shall dine with you with much pleasure.
7. A blind man does not require to see to eat.
8. It is better to laugh than cry.
9. He won his suit, and gave a big dinner.
10. Deaf mutes can speak with their fingers.
11. The actor declaimed very well.
12. Canaries sing, and dogs bark.
13. When we go to the orchard we eat fruit.

Continued

LIVING FLOWERS OF THE SEA

THE SIMPLEST FORMS OF LIFE

Sea-lilies, Starfishes, and Sea-urchins. Sea-anemones. The Life History of a Coral. Jelly-fishes. Sponges. Animalcules. The Origin of Limestone

continued from page 3960

By Professor J. R. AINSWORTH DAVIS

ECHINODERMS, or hedgehog-skinned animals [see Plate facing], differ from all the forms so far considered in the nature of their symmetry. Instead of being two-sided, with a well-marked distinction between right and left and front and back (bilateral symmetry), they resemble a star or regular flower in shape, as in **550**. The skin is hardened by the deposition of salts of lime, and the body is often covered with spines, as more particularly in sea-urchins [**544**].

Five existing subdivisions are recognised: (1) Sea-lilies and feather-stars (*Crinoidea*); (2) starfishes (*Asteroidea*); (3) brittle stars (*Ophiuroidea*); (4) sea-urchins (*Echinoidea*); and (5) sea-cucumbers (*Holothuroidea*). All are marine.

Sea-lilies. Sea-lilies are deep-sea animals, once numerous and flourishing, but now comparatively rare, and only to be obtained by dredging in the deeper parts of the ocean. They are fixed by a long jointed stalk bearing circlets of sensitive threads and terminating in a cup, in the centre of which the mouth is situated [**547**]. Radiating from the edges of the cup are five branching, feather-like arms, all of which are grooved above, the grooves uniting, and finally converging to the mouth. They are beset with cilia, and minute organisms are conducted inwards along them to serve as food. Owing to their sedentary mode of life, the once abundant sea-lilies are now on the way to extinction.

"LIVING FLOWERS OF THE SEA"
[*See Plate opposite*]

A. Aiptasia Couchii The trumplet anemone
A1. Echinus miliaris -Purple-tipped sea-urchin
B. Sagartia viduata -Snake-locked anemone
B1. Sagartia chrysosplenium Gold-spangled anemone
C. Ophiocoma rosula- Brittle starfish
D. Actinoloba dianthus— Plumose anemone
E. Sagartia miniata—Scarlet-fringed anemone
F. Bunodes coronata Diadem pimplet anemone
G. Actinia mesembryanthemum—Beadlet anemone
G1 & G2. Other varieties of G
H. Anthea cereus -The opelet anemone
J. Comatula rosacea- Pink feather-star on tube of sabella
K. Synapta digitata —A sea-cucumber
L. Corynactis viridis- The globehorn anemone
M. Bunodes thallia —Glaucous pimplet anemone
N. Tealia crassicornis—Dahlia wartlet anemone
O. Lophohelia prolifera -Tuft coral
P. Sagartia parasitica- Parasitic anemone on whelk shell containing hermit crab
Q. Euplectella aspergillum —Venus's Flower-basket —A glass sponge
R. Stomphia Churchiæ- Gapelet anemone
S. Serpula contortuplicata -Colony of a tube forming Annelid
T. Peachia hastata- Arrow muzzlet. Body in sand
T1. " " " " Body exposed
U. Cucumaria Hyndmanni—Sea-cucumber
V. Asterias rubens—Five-finger starfish
W. Caryophyllia Smithii —Devonshire cup-coral
W1. & W2. " " " " " closed
X. Balanophyllia regia—Scarlet and gold star-coral
X1. " " " " " closed
Y. Sipunculus Bernhardus, a siphon-worm in shell of turritella, on which is colony of balani
Z. Thalassema Neptuni— a siphon-worm

Feather-stars. The closely related feather-stars [**548**], however, flourish exceedingly, for they have given up the stalk, and are able to swim about actively by bending and straightening their long arms. They can also hold fast to seaweed, or even climb by means of a whorl of jointed threads attached to the under side of the cup, and representing one of the numerous circlets to be found on the stalk of a sea-lily.

The life-history of the individual often affords a clue to the geological history of its group. The feather-star is a particularly good example of this, for in early life it is a stalked larva [**538**], closely resembling a minute sea-lily. After a time the stalk is cast off, and a fixed life exchanged for an active one. The best-known species (*Comatula rosacea*) is bright red in colour, and very conspicuous—another example of that "warning coloration" which denotes inedibility.

Starfishes. Starfishes are among the most familiar objects of the seashore, and the commonest kinds, such as the five-finger (*Asterias rubens*) and the comb-star (*Astropecten aurantiacus* [**550**], possess five radiating arms. The mouth is in the centre of the under side, and leads into a capacious stomach [**540**], of which the first part can be protruded from the body to surround such prey as mussels and oysters.

A starfish crawls slowly by means of numerous *tube-feet*, which are lodged in five grooves radiating from the mouth [**550**], and make up a part of the *water vascular system*, so called because it is full of sea-water. Some of the details will be understood by reference to **540**. On the upper side of the central disc, in the interval between two of the arms, is a furrowed *madreporic plate*, perforated like the top of a pepper castor. Sea-water continually flows through it into a calcified stone canal which opens below into a ring canal running round the gullet. From this a radial canal runs along each arm-groove, and bears a double series of tube-feet (only one set is shown in **540**).

There is a little swelling (*ampulla*) at the base of each tube-foot, and by its contraction water is forced into the foot, which is thus extended. In the common five-finger and many others the tube-feet end in adhesive suckers, which materially aid crawling over rock and weed. But in the comb-star [**540**] the feet are pointed, and adapted for progression on sand. At the end of each arm is an unpaired tube-foot acting as a feeler, while on its under side there is an orange-red eye-spot.

Remarkable Powers of the Starfish.

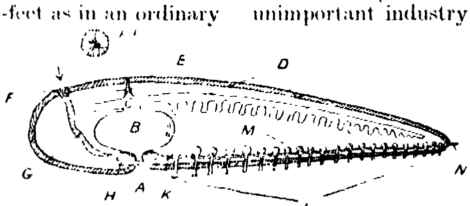
The water vascular system also assists in breathing. It was probably first evolved in the interests of respiration, and this is its chief use in the sea-lily. Some of the spines are formed of little two-bladed pincers, which clean the surface of the body.

A starfish hatches from the egg as a two-sided *bipinnaria* larva, the body of which is drawn into soft arms [**539**] covered with cilia. After a time two rounded thickenings appear in its skin, one on each side. These are the beginnings of the adult body, which appropriates the stomach and some other of the larval organs, while the rest of these, including the soft arms, are absorbed.

538. STALKED LARVA OF FEATHER-STAR
a, *b*, and *c* show three successive stages

Starfishes are remarkable for their powers of restoring lost parts. A detached arm can grow a fresh disc and another four arms.

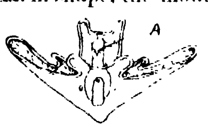
Brittle Stars. The arms of an ordinary starfish are merely continuations of the central disc, and glandular prolongations of the stomach extend into them. But this is not the case in a brittle star [**549**], where the arms are slender, extremely mobile appendages, which are readily detached. They are the agents of locomotion, one being kept to the front, while the others "row" the body rapidly along over sand or seaweed in a somewhat spasmodic fashion. There is no crawling by means of tube-feet as in an ordinary starfish, and on examining the under side of the body the five-rayed mouth will be seen [**549**], but no grooves below the arms. These, in fact, have been floored-in by plates, at the sides of which project the tube-feet, used in this case only for breathing and as feelers.



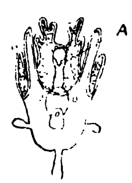
540. DIAGRAMMATIC VERTICAL SECTION THROUGH A STARFISH
a. Mouth *b*. First, and *c* second parts of stomach *d* Glandular branch of stomach *e*. Intestine *f*. Madreporic plate *f1* Surface view of same (enlarged) *g*. Stone canal *h*. Water vascular ring *k*. Radial canal *l*. Tube-feet *m*. Vesicles of tube-feet *n*. Tentacle

A brittle star hatches out as a *pluteus larva* [**541**], with stiff arms supported by calcareous rods. The adult body arises in much the same way as in an ordinary starfish.

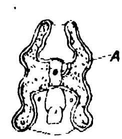
The Sea-urchin. An ordinary or *regular* sea urchin [**544**] is spheroidal in shape, the mouth being in the centre of the under side. The calcareous plates in the skin are very regularly arranged in twenty series running from the upper to the lower pole, and disposed in ten double sets, comparable to the "gores" of a balloon. Five of these sets are perforated by minute holes through which the tube-feet project. These are used for crawling and climbing. The body is covered with numerous spines attached by ball-and-socket joints. They constitute formidable defences, and in some tropical species can effect poisoned wounds. Many of the spines are modified into little pincers, as in starfishes, but in this case there are three instead of two jaws.



541. PLUTEUS LARVA OF BRITTLE STAR
a. Mouth

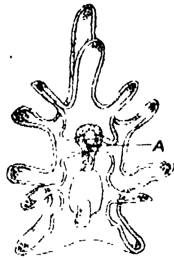


542. PLUTEUS LARVA OF SEA-URCHIN
a. Mouth



543. AURICULARIA LARVA OF SEA-CUCUMBER
a. Mouth

A regular sea-urchin feeds upon seaweed and the small animals attached thereto, and to deal with these there is a complicated biting arrangement consisting of five pointed teeth (which grow continuously like the front teeth of a rabbit), and numerous plates for the attachment of chewing muscles. The whole arrangement when dissected out looks like an antique lantern, and is, in fact, known as "Aristotle's lantern."



539. BIPINNARIA LARVA
a Mouth

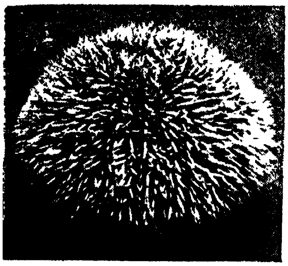
The *irregular* sea-urchins [**546**] are of more specialised nature, and markedly two-sided, as well as more or less flattened. The mouth has been shifted forwards towards the front, and is devoid of any chewing apparatus, here unnecessary, for the food consists of the nutritious matter contained in sand, which is swallowed in large quantities.

A sea-urchin hatches out as a *pluteus larva* [**542**], which differs in detail from that of a brittle star. The egg-producing organs or ovaries of sea-urchins are valued as food by some of the primitive coast-dwelling peoples, such as Fuegians, and are the object of a not unimportant industry in the West Indies.

Life on the Floor of the Sea. Sea-cucumbers are elongated tough-skinned creatures [**545**] which crawl on the sea-floor or burrow in its deposits, and are much more muscular than other hedgehog-skinned animals. The mouth, at one end of the body, is surrounded by blunt tentacles which help to shovel food into it. The skin is hardened by lime to a less extent than in the groups so far considered, but contains scattered plates of characteristic form, resembling wheels, anchors, etc., and making attractive microscopic objects. The tube-feet are generally arranged in five longitudinal bands, though they are sometimes scattered over the surface of the body [**545**], or, more rarely, they may be entirely absent. In some forms which creep on the floor of the deep sea there is a well-marked distinction between upper and under sides, the latter being flat, and reminding one of the muscular foot of a snail.

A sea-cucumber begins life as an *auricularia* larva [**543**], which is of somewhat simpler character than the larvæ of starfishes and sea-urchins.

The dried bodies of sea-cucumbers, commercially known as trepang or *bêche-de-mer*, are


544. REGULAR SEA-URCHIN

545. SEA-CUCUMBER *a.* Mouth


546. IRREGULAR SEA-URCHIN

largely used as food by the Chinese and some other Eastern peoples. One of the most important trepang fisheries is that of the Great Barrier Reef, off the east coast of Australia.

ZOOPHYTES

"Simply a Stomach." Zoophytes (*Cœlenterata*) [see Plate facing page 4081], of which sea-anemones, corals, and jelly-fishes are familiar examples, are distinguished by the ray-like symmetry we have already noticed among starfishes and their kind, though here, as a rule, it is more perfect. In structure they are much simpler than any of the animals so far considered. For such a creature is to all intents and purposes simply a stomach, the wall of which is made up of two layers of cells, one (*ectoderm*) external, and the other (*endoderm*) internal. In higher animals a third layer (*mesoderm*) is interposed.

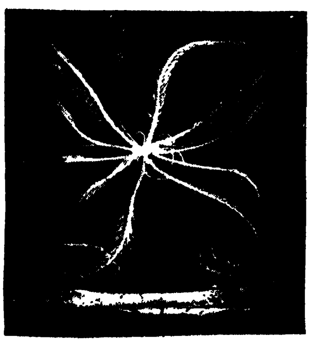
The ectoderm is studded with innumerable microscopic capsules (*thread-cells*), from which poisoned threads with barbed bases can be shot out, serving as formidable weapons of offence and defence. These assist in procuring food, which consists of crustaceans, small fishes, and various other animals, for these creatures are highly carnivorous.

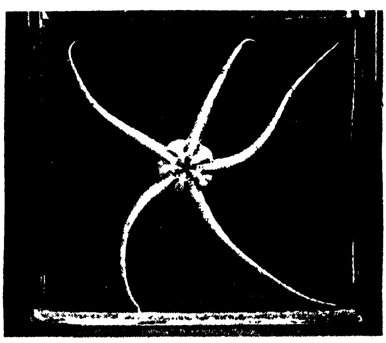

547. SEA-LILY

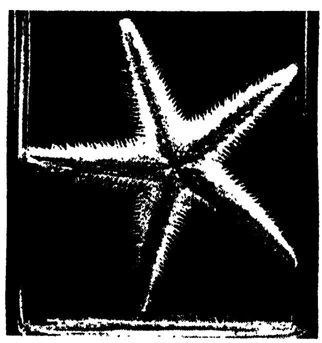
The name "zoophyte" (Greek: *zoon*, animal; *phyton*, plant) was originally applied to some of the fixed members of this group at a time when their animal character was a matter of doubt. Two chief sub-divisions are recognised: (1) Sea-flowers (*Anthozoa*); and (2) Hydroids (*Hydrozoa*).

Sea-flowers. Visitors to the seashore certainly will have noticed coloured jelly-like blobs, adhering to rocks, and opening out when placed in water, exhibiting a central mouth surrounded by circlets of tentacles. These are the sea-anemones [see Plate facing page 4081], which well deserve their name, for they are very flower-like in appearance. Mention has been made on page 3808 of the way in which some of them are associated with crabs and hermit crabs. The mouth of a sea-anemone leads into a short gullet, that hangs down into the cavity of the body, with the wall of which it is connected by radiating fleshy partitions (*mesenteries*) Between these are numerous smaller structures of the same kind as project from the body-wall only part of the way to the gullet.

One of the largest of our native anemones (*Tealia*) has sticky knobs on its body to which small stones adhere to form a protective covering. When the animal is shut up or retracted it is very inconspicuous, looking like a small heap of fine gravel. It may be noted in passing that the bright colours which distinguish anemones and their kind are probably of "warning" nature, such as advertise unpleasant properties, in this case the ability to sting. Anemones, and the same is true for other zoophytes, propagate not merely by eggs, but also by budding (*gemmation*) and splitting (*fission*), especially the latter, which may often be seen in process in a marine aquarium. In anemones, however, the products do not remain united to form a colony.

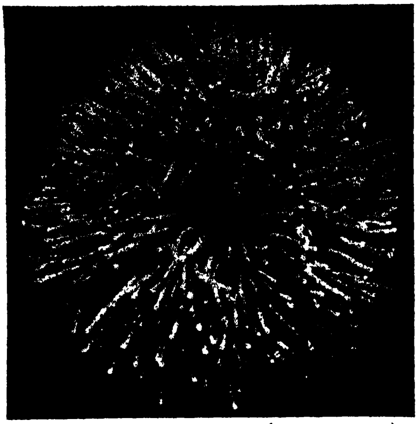

548. FEATHER-STAR


549. BRITTLE STAR (UNDER SIDE)

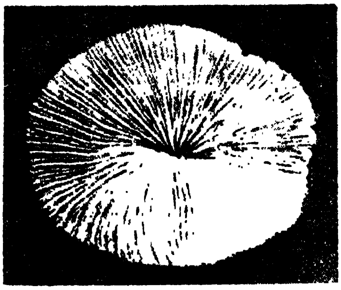

550. STARFISH (UNDER SIDE)

(Photographs by Prof. B. H. Bentley)

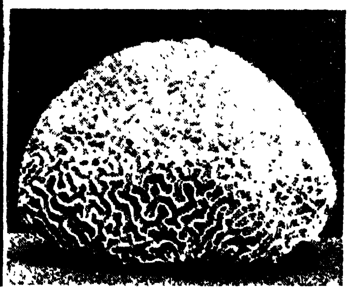
Corals. *Corals* are closely related to sea anemones, but differ from them by secreting a hard limy skeleton in the base of the body. They are either *simple* or *compound* (colonial). The well-known mushroom coral may be taken as an example of the former. Its skeleton is a shallow cup [552], exhibiting numerous radiating plates (*septa*), corresponding to the intervals between the fleshy mesenteries of the polype. If we look at the upper surface of such a coral in the living state [551], we shall see a mouth surrounded by circlets of tentacles, much as in a sea anemone.


551. MUSHROOM CORAL (SOFT PARTS)

A *colonial* coral consists of a number of individuals, relatively small in size, connected together by a common flesh (*cœnosarc*), and formed by the budding or splitting of a single original polype, the results of the process remaining united. Part of such a coral (*Siderastræa*) is here figured [555], showing four polypes and the calcareous cups from which several others have been scraped away.

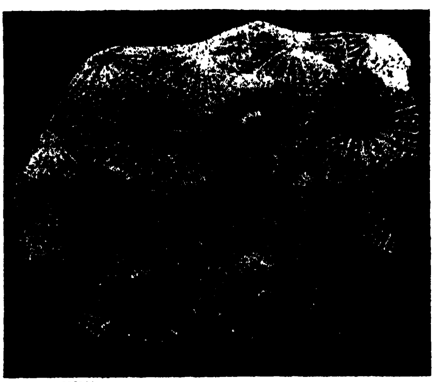

552. MUSHROOM CORAL (SKELETON)


553. BRANCHING CORAL


554. BRAIN CORAL

(Photographs by Prof. B. H. Bentley)

Development of Coral. Another figure is given [556] in illustration of the life-history of the last-named coral. An elongated ciliated larva hatches from the egg, and after swimming about for some time fixes itself to some firm object, and develops the tentacles and mesenteries characteristic of the adult. It will be noticed that the tentacles are at first clearly arranged in sixes, and the same thing is true of the mesenteries, the position of which is indicated by lines.

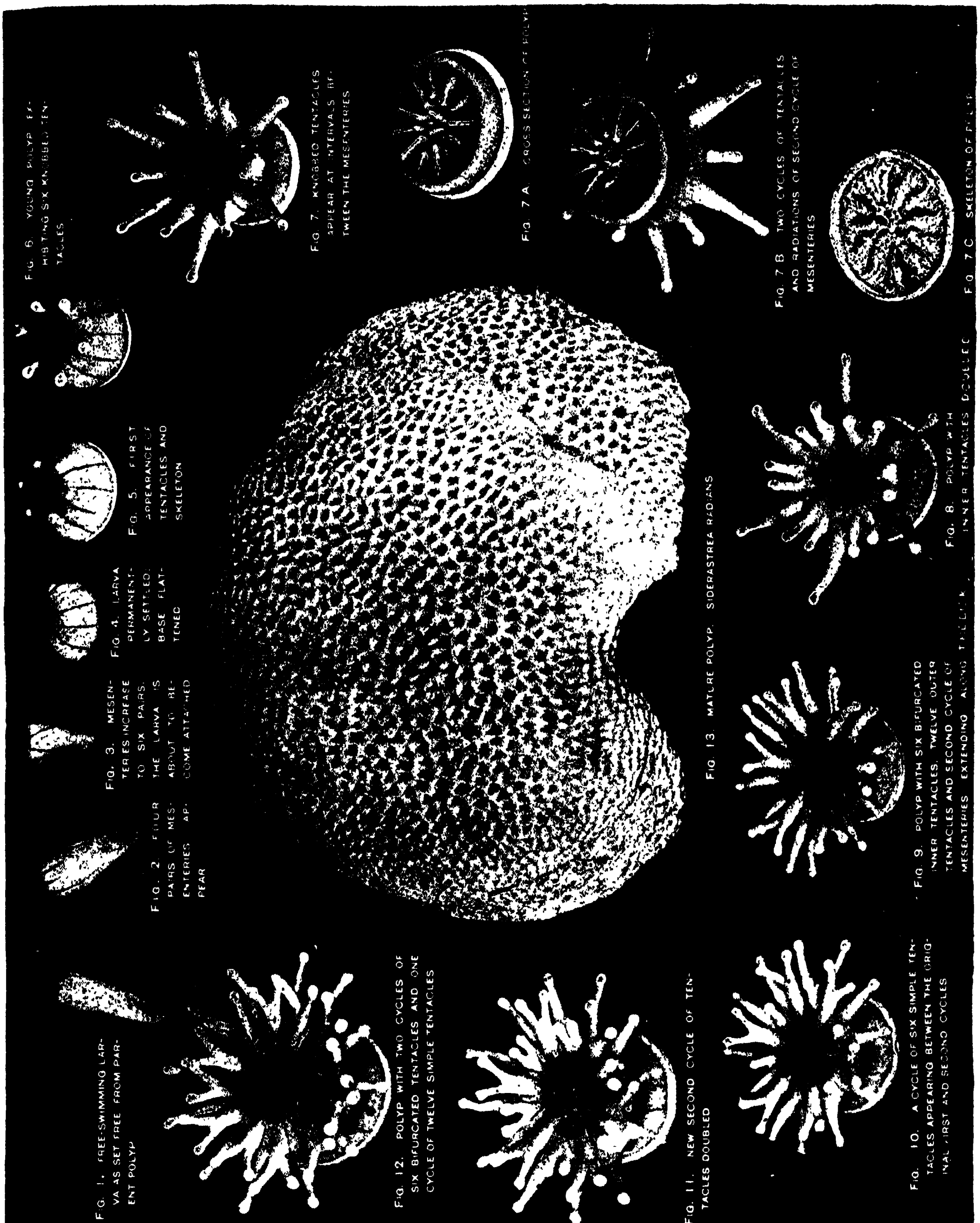

555. PART OF COLONIAL CORAL

Many corals branch [553], while others form compact masses, as in the kind above described, and also in the brain coral [554], where the boundaries between the individuals are not clearly marked.

Coral Reefs. Corals are marine creatures widely distributed, some living even in cold latitudes, and others on the floor of the deep sea. Coral reefs, however, made up of the skeletons of such animals, are only found in the warmer parts of the ocean, where the water is clear, particularly favourable conditions being afforded by the Pacific and Indian Oceans. Three varieties of coral reef may be distinguished: (1) Fringing Reefs, situated close to the land and separated from it by shallow water; (2) barrier reefs, further from the land and separated from it by deeper water (when round an island they are termed *encircling reefs*); (3) atolls, rings of coral with a central lagoon much shallower than the surrounding water.

Much discussion has taken place regarding the origin of coral reefs. It is known that the polypes can only live and flourish in comparatively shallow water, yet barrier reefs and atolls make up walls of coral which descend for hundreds, or even thousands, of feet into the depths. How is this to be accounted for? Darwin supplied the most plausible explanation, which certainly applies to a great number of cases. It may best be illustrated by taking the case of an island.

A Skeleton Island. There is no difficulty in understanding how a fringing reef can be formed round the shores of an island if we bear in mind that it is slowly sinking. Such slow downward movements are known to have taken and to be taking place in various parts



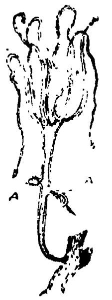
556. LIFE HISTORY OF A CORAL

of the world. As depression goes on, the corals will continue building on the dead skeletons of their predecessors, and after a time will form an encircling reef, with the remains of the island in the centre. When this is finally submerged, the atoll stage is reached.

Dead Men's Fingers. We now come to sea-flowers of another kind, in which there are *eight* feathery tentacles, and a corresponding number of mesenteries. All of them are colonial. One of the commonest examples is afforded by lobed fleshy masses often cast up on our shores, and known by the rather depressing name of dead men's fingers (*Alcyonium*). When expanded, these are very attractive in appearance [567], the individual polypes projecting like little flowers from the fleshy common body. In this case the skeleton consists of scattered

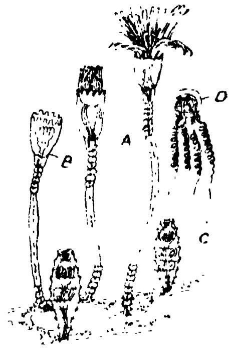
spicules of lime. In some of the related forms, however, it is of more compact character.

In the red or precious coral (*Corallium rubrum*), for instance, the branching colony is supported by a firm limy skeleton of pink colour. This is covered by the common flesh, from which the polypes can be protruded much as in alcyonium. Somewhat similar in general character is the fan-coral (*Gorgonia*), of which the curious horny skeleton [563] is often brought home by sailors. Much more beautiful is the organ-pipe coral (*Tubipora musica*), where each member of the colony lives in an elegant red tube [**564**]. The tubes are connected by thin platforms at regular intervals, and from these new polypes grow up, so that the colony gradually increases in size from the base upwards.

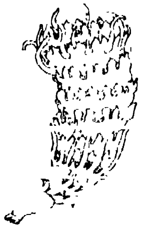


557. FRESHWATER POLYPE Buds

Growth on Seaweeds. Growing upon seaweeds, and often cast up by storms on the shore, will be seen branching structures, frequently mistaken for plants, and technically known as *hydroid zoophytes*, of which an example (magnified) is figured in **558**. The branches of the apparent plant are horny tubes, enclosing the common flesh of the colony, and in this case they end in little cups which shelter the individual polypes. Each of these resembles a simplified sea-anemone in structure. It has fewer tentacles, and is devoid of a gullet and mesenteries. The life-history of the form known as *Campanularia* [558]) is of special interest.

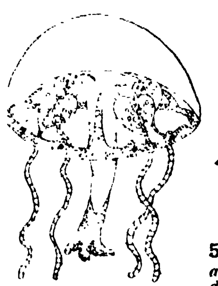


558. HYDROID ZOOPHYTE
a. Extended polype
b. Retracted polype
c. Urn *d.* Jelly-fish



559. HYDROID POLYPE SPLITTING TRANSVERSELY

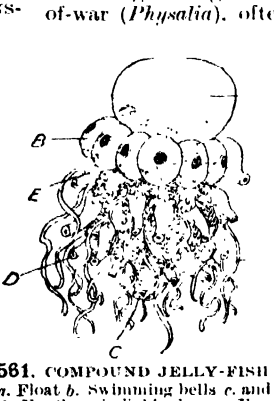
Umbrella - like Jelly-fishes. Attached to the base of the colony are elegant urn-shaped receptacles, in which buds of special character are produced, destined to be liberated as free-swimming jelly-fishes (*Medusæ*), representing the egg-bearing stage. Free-swimming larvæ develop from the eggs, which after a time settle down and give rise to fixed branching colonies. Such a life-history is an example of "alternation of generations," as previously described for many plants and some of the parasitic worms. That is to say, it includes an egg-producing stage, and a stage which propagates by budding or splitting. In the last form described, the medusæ are produced by budding, but in some other cases they arise by a process of splitting. This is illustrated by **559**, which shows a fixed polype dividing transversely into a number of little **jelly-fishes. A jelly-fish, or medusa, may be compared to a fleshy umbrella with a thickened handle, at the end of which the mouth is situated [560]. Swimming is effected by the opening and shutting of the umbrella.**



560. JELLY-FISH

Pond - dwelling Polypes. There are some hydroid zoophytes in which the medusæ are never set free, and still others in which the egg-producing buds are more or less unlike medusæ in form. An extreme case is afforded by the fresh-water polype (*Hydra*), one of the common inhabitants of ponds [**557**], and a simple, not a colonial, organism. During the summer this animal propagates by buds, which are detached when mature; but on the approach of autumn one or two small rounded prominences appear on the basal part of its body, and in each of these an egg is formed. This surrounds itself with a horny coat, falls down into the mud of the pond, and remains in a dormant state during the winter, when most of the adults perish.

Most of the larger jelly-fishes [560], such as may be seen swimming in shoals during the summer, or stranded on our shores, have no fixed stage in the life-history, their eggs developing at once into new jelly-fishes. There are also many colonial jelly-fishes in existence, differing ends being served by different members of the colony. In the example figured [**561**] the top individual is a float, beneath which is a series of swimming-bells, and below these again are feeding and egg-producing individuals, some of which are provided with long fishing lines. The Portuguese Man-of-war (*Physalia*), often mentioned in accounts of voyages, is a compound jelly-fish, provided with a particularly large float.



561. COMPOUND JELLY-FISH
a. Float *b.* Swimming bells *c.* and *d.* Feeding individuals *e.* Egg-producing buds *f.* Fishing-line

A few of the relatives of the hydroid zoophytes secrete a calcareous skeleton, and rank as corals. A common form is Millepora [**565**].

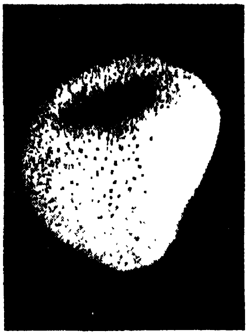
SPONGES

Sponges (*Porifera*) are animals of peculiar structure, which resemble zoophytes in many respects, but possess neither tentacles nor thread-cells. Some are simple, but most of them are colonial. A simple sponge may be compared to a cup or vase with a wall perforated by numerous small holes, through which currents of sea-water stream into the central cavity, to make their exit by the main opening. They are set up by ciliary action. The

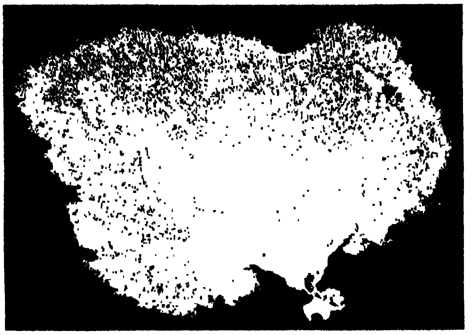
horny skeleton of a simple cup sponge is represented in 562. The ordinary bath-sponge is the similar skeleton of a colonial form.

Venus's Flower-Basket. In the majority of cases the skeleton of a sponge is mostly or entirely made up of sharp needles of lime or flint, which may be welded together into a definite form. A very beautiful deep-sea siliceous sponge of the kind is Venus's Flower-basket (*Euplectella*), the figure of which [566] shows very clearly the small holes into which the currents of water stream. In this case the opening of the vase is provided with a convex perforated covering. Another elegant form is the Glass-rope Sponge (*Hyalonema*), native to the Japanese seas [568]. It is rooted in the mud by a bundle of long glassy spicules, which are slightly twisted.

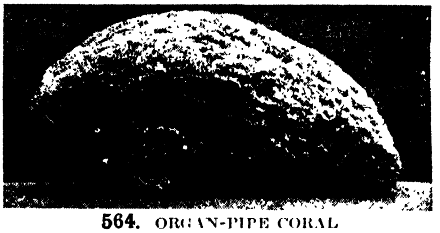
Most sponges are marine, and, despite their fixed habit and apparent helplessness, are pretty free from the attacks of most other creatures partly because of the innumerable sharp spicules they contain, and partly because their taste and smell are unpleasant. These deterrent qualities are often associ-



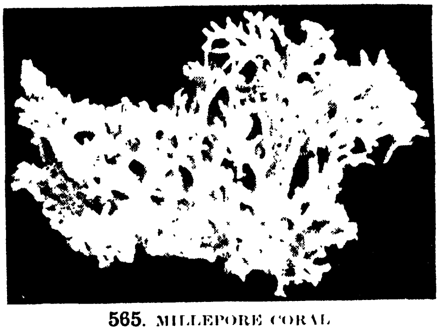
562. CUP SPONGE
(With horny skeleton)



563. FAN CORAL
(Gorgonia)



564. ORGAN-PIPE CORAL
(Tubipora)



565. MILLEPORE CORAL
(Millepora)

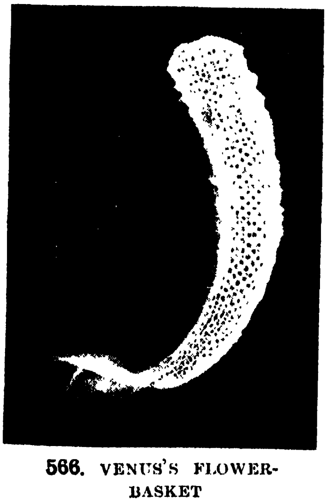
ated with bright warning colours, generally red, yellow, or orange. The relations of some crabs to sponges has been mentioned on page 3808.

A few sponges of greenish colour live in canals or slowly-moving streams, attached to various firm objects. Like so many fresh-water organisms, they have a special device for tiding over the winter, which is very destructive to the adults. Towards autumn they develop little internal buds (*gemmules*), enclosed in cases made of peculiar spicules, shaped something like two little stars united by a rod. These buds remain snugly in the mud till the winter is over, and then sprout into adult sponges.

ANIMALCULES

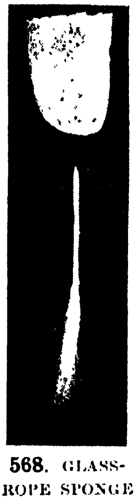
In the botanical part of this course we found that the lowest plants are mostly of a microscopic size, and *unicellular*—*i.e.*, consisting of a single cell or structural unit, essentially a fragment of living matter (protoplasm), part of which is specialised into a nucleus. The latter appears to regulate the vital activities.

Amœba. The lowest animals are also unicellular, and the popular term "animalcule"—*i.e.*, a little animal—has reference to their diminutive size. One of the simplest known cases is afforded by the Proteus Animalcule (*Amœba*), a mere droplet of semifluid substance without any definite form [569], or more correctly with a form that is constantly altering. Animalcules of



566. VENUS'S FLOWER-BASKET

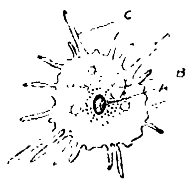
567. DEAD MEN'S FINGERS



568. GLASS-ROPE SPONGE

the kind are common enough in both salt and fresh water, and may be found crawling over mud or weed. The crawling is better described as a flowing along, the substance of the body protruding in finger-like lobes, known as *pseudopods* (false feet). The nucleus can easily be seen as a rounded particle, and there is also a clear space, of which the size alternately increases and diminishes, on which account it is called the "pulsating vacuole." It communicates with the exterior, and probably has to do with breathing and the getting rid of waste products in general.

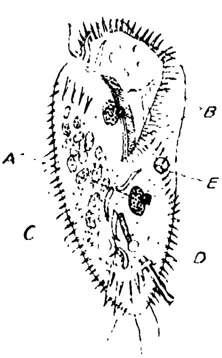
Creatures that Never Die. Amœba feeds by flowing round various objects—mostly minute plants—and digesting them in its interior. The undigested or indigestible remnants are cast out at any point, or, in other words, the animal flows away from them. Propagation takes place by a process of splitting into halves, the nucleus taking the lead. Each half is a new individual, which later will divide in its turn. It is possible that death as such, excepting the case of accident, does not take place in some creatures of this kind, hence the well-known expression "immortality of the Protozoa."



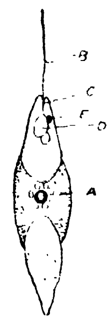
569. PROTEUS ANIMALCULE
a. Nucleus *b.* Pulsating vacuole *c.* Pseudopods

Under unfavourable circumstances the Amœba assumes a rounded form, and secretes a firm membrane, or *cyst*, around its body. Within this it remains dormant till better times return, when the cyst is ruptured, and it crawls out again.

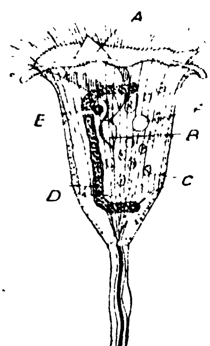
Some of the immediate relatives of Amœba live within a kind of shell, and this leads on to the animalcules known as Foraminifera, in which an elegant calcareous shell is present [574]. These creatures float in vast numbers in the surface layers of the sea, and their pseudopods are slender radiating threads which fuse together in places. The shells of many are perforated by innumerable minute pores, hence the name of the group (Latin: *foramina*, little holes).



570. FREE-SWIMMING CILIATE
a. Nuclei (with rounded paranuclei) *b.* Mouth-groove *c.* Food *d.* Ejection-point *e.* Pulsating vacuole



571. EUGLENA
a. Nucleus *b.* Flagellum *c.* Mouth *d.* Pulsating vacuole *e.* Eye-spot



572. BELL ANIMALCULE
a. Mouth *b.* Gullet *c.* Food *d.* Nucleus *e.* Paranucleus *f.* Pulsating vacuole

A Rain of Shells in the Sea. The most interesting feature in connection with the Foraminifera is the part they have played in building up many of the limestones which help to compose the hard framework of the globe. We know that at the present time a fine rain, so to speak, of their shells is constantly falling on the sea floor, and accumulating into limy oozes. Examination under the microscope of chalk, which is a very pure limestone, shows that it mainly consists of such shells, which accumulated in an ancient sea that stretched from what is now the Atlantic eastward through South Europe to Asia.

Certain extinct members of the group were of comparatively large size and shaped like coins. These Nummulites (Latin: *nummus*, a coin; Greek: *lithos*, a stone), are the main constituents of a limestone which plays an important part in the architecture of such important mountain ranges as the Alps and Himalayas [573]. [For details see GEOLOGY.]

Ray Animalcules (*Radiolaria*). Ray animalcules [575] are forms which resemble the members of the last group in some respects, but are more complex in structure, with shells composed of a lattice-work of flinty matter. These shells cover large tracts of the floor of the deeper parts of the ocean (limy shells dissolve before getting so far), and make up "Radiolarian oozes." What is mentioned as *Barbadoes earth* in catalogues of microscopic slides is really an ancient deposit of this kind, which has been upheaved above sea-level.

Flagellates. Flagellates are immensely numerous animalcules with a body of definite shape covered by a membrane. Swimming is effected by a slender thread or *flagellum* (Latin for whip-lash) of living substance, which executes whip-like movements. The example figured, Euglena [571], is common in ponds and ditches, where it often makes up a green scum. A mouth is situated at the base of the flagellum, and at this end there is also a red eye-spot. Some flagellates bear more than one flagellum, many are fixed, and the colonial condition is common. The exceedingly minute animalcules which swarm in putrid fluids and are vaguely known as "monads" belong to this group.

Among flagellates and the remaining Protozoa to be dealt with *conjugation* is a common phenomenon. Two individuals meet together and either fuse permanently or exchange some portion of nuclear substance. In either case activity is stimulated, one result being an increase in the rapidity of propagation by splitting.

Ciliates. Ciliates, like flagellates, are invested in a firm membrane, and therefore of definite form. Instead of flagella they possess *cilia*, short threads of living substance which are associated in large numbers, and alternately bend and straighten in a rhythmic fashion, bringing about locomotion in free

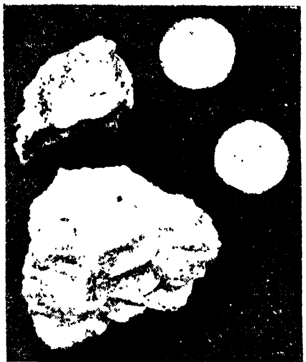
species or setting up currents in the surrounding water in fixed ones.

A free-swimming ciliate is figured in **570** and in this case it will be noticed that there are two nuclei though only one pulsating vacuole. In some other ciliates the reverse is true. Near each nucleus is a small, round *paranucleus*. Upon the under side of the body there is a ciliated groove leading to the mouth. The undigested remnants of the food are cast out from a point where the covering membrane is absent.

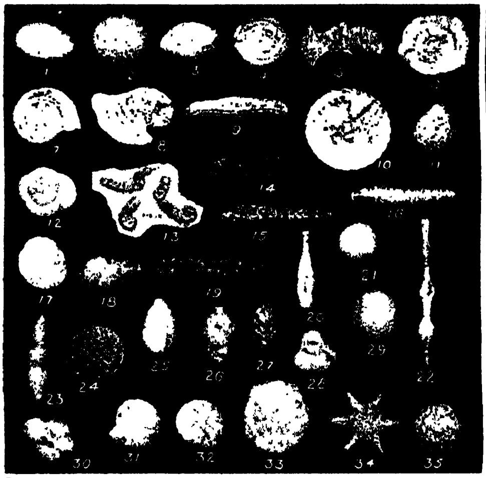
To illustrate the fixed ciliates, some of which are colonial, we may take a Bell Animalcule [**572**]. This is fixed by a stalk containing a muscular thread, by the shortening of which the stalk can be wound up into a spiral coil. The broad end of the body is fringed by cilia that set up food-bearing currents. The nucleus is a long, curved band, but the paranucleus is a rounded particle.

Parasites. Spore-producing animalcules are parasitic forms which reproduce by "spores," the body breaking up into a number of minute portions, surrounded by firm membranes, and easily diffused by currents of air or water. It is, therefore, no wonder that these little creatures are very widely distributed.

It has been proved of late years that a number of malignant diseases are due to spore-producing animalcules, which attack the red corpuscles of the blood and cause their disintegration. Examples are malarial and yellow fevers, the "fly sickness" of horses in South Africa, and the fatal sleeping sickness of Uganda and other parts of tropical Africa. The parasites which produce these diseases have a complicated life-history, partly spent within a warm-blooded backboned animal, and partly in some lower form, generally a fly or mosquito. Supposing, for example, a mosquito infested with the animalcule of yellow fever bites a human being, a certain stage in the development of the parasite is thereby introduced into the blood, and is able to pass into another stage, by which the fever is set up. But the mosquito, in its turn, when it attacks a diseased human being, also contracts its own phase of the disease.



573. NUMMULITES AND NUMMULITIC LIMESTONE (Photo by Prof. B. Bentley)



574. FORAMINIFERA

1. Biloculina. 2. Biloculina. 3. Miliolina. 4. Spiroloculina. 5. Vertebralina. 6. Hauerina. 7. Cornuspira. 8. Peneroplis 9. Alveolina. 10. Orbitolites. 11. Saccammina. 12. Trochammina. 13. Placopsilina. 14. Textularia. 15. Clavulina. 16. Bigenerina. 17. Cassidulina. 18. Bulimina. 19. Gaudryina. 20. Lagena. 21. Lagena. 22. Nodosaria. 23. Nodosaria. 24. Cristellaria. 25. Polymorphina. 26. Uvigerina. 27. Tritaxia. 28. Globigerina. 29. Orbulina. 30. Pullenia. 31. Rotalia. 32. Truncatulina. 33. Planorbulina. 34. Tenoporus. 35. Pulvinulina. (Photograph by Prof. B. H. Bentley)

Yellow Fever. When the cause of a disease is known we are a long way on towards finding a cure, or, still better, some preventive measures, that in the case of yellow fever and the like obviously consist in exterminating the mosquito which unconsciously disseminates the malady. And probably the time is not very far distant when many tropical complaints due to microscopic parasites, and particularly fatal to Europeans, will be largely checked if not entirely stamped out. Indeed, a beginning has already been made in this direction.

575. RADIOLARIANS

The Optimism of Nature. We have now acquainted ourselves with some of the chief facts of Natural History, and anyone inclined to doubt its value will do well to ponder over the words of Huxley, that if this be omitted from education, "you launch the student into the world undisciplined in that science whose subject-matter would best develop his powers of observation; ignorant of facts of the deepest importance for his own and others' welfare; blind to the richest sources of beauty in God's creation; and unprovided with that belief in a living law, and an order manifesting itself in and through endless change and variety, which might serve to check and moderate that phase of despair through which, if he take an earnest interest in social problems, he will assuredly sooner or later pass."

Natural History concluded; followed by APPLIED BOTANY

Group 24
PHYSICS
29

Continued from page 3945

THE WONDERFUL RÖNTGEN RAYS

The Discovery of the Röntgen Rays, and their Use in Surgery. Their Benefit to Humanity, and Theories Concerning their Effects

By Dr. C. W. SALEEBY

WE are already quite familiar with the fact that the radiations called light have variously been conceived as consisting of undulations or vibrations in the ether, or of minute material particles moving through space at high speeds. We know, also, that the latter or Newtonian view is now disproved; but it is extremely important for us to recognise that the word *radiation* is now used in physical science to cover two very different things—first, various wave motions in the ether; and, secondly, various corpuscular motions which are not light but which have a very striking resemblance to Newton's theory of light. We may quote from Mr. Soddy, one of the most distinguished of the workers in this field, a definition of the use of the word radiation in its wide modern sense. He says "the term *radiation* is properly applied to indicate an influence transmitted *radially* from its source to its surroundings, and capable of traversing vacuous space without occupying in its transmission a period of time great enough to be sensible under ordinary circumstances." The reader will not be misled by Mr. Soddy's use of the word *vacuous*. It means vacuous as regards ponderable matter, but certainly not vacuous as regards the ether.

The Work of Sir William Crookes. It was Sir William Crookes who first recognised the existence of radiations more or less corresponding to the type imagined by Newton. In order to understand his discovery, we must briefly note the elementary facts of a vacuum tube. An electric current can be made, under favourable conditions, to spark across a gap of air, but a very great measure of electric force is necessary to maintain any appreciable discharge across even a very small interval of air at the atmospheric pressure, while a still greater force is needed to start the process. The passage of the spark is made very much easier by lowering the atmospheric pressure. This can be easily shown by sealing platinum wires, which act as electrodes, or conveyers of electricity, into small glass tubes, most of the air of which has been removed. But at this point we cannot do better than quote from another distinguished worker in this field, Mr. Whetham.

"For many years these vacuum tubes, as they are called, were the electrical playthings of the laboratory and popular lecture-room. Recent discoveries have raised them from the position of scientific toys to the rank of pieces of apparatus whereby have been made some of the greatest discoveries in physical knowledge that the present generation has seen. Through such a tube, in which the pressure of the air is only a small part of an atmosphere, a discharge may readily be passed by the aid of a voltaic battery and an induction coil, or by the use of an influence electric machine. As in liquid conductors, the electrode by which the current enters is called the *anode*, and that by which it leaves, the *cathode*. Starting from the cathode, we first see a bright glow covering its surface, then a space, succeeded by a second dark space, beyond which is a luminous column reaching to the anode. Within certain limits of pressure and strength of current this positive column, as it has been called, shows fluctuating striations. If the length of the tube be increased, it is this positive column alone which increases with it; the two dark spaces and the negative glow vary very little with the length of the tube."

The Cathode Rays. Sir William Crookes proceeded to study the consequences of making the vacuum in such a tube extremely high, and he discovered, as certain of his predecessors had suspected, that certain rays are produced, which we now know as *cathode* rays. The greater the exhaustion of the tube the greater becomes the size of the dark space or "Crookes' dark space," around the cathode. At last this fills the whole tube, and the glass opposite the cathode begins to display a green phosphorescent appearance. Furthermore, if a mica screen be interposed between the phosphorescent glass and the cathode, a shadow which is notable for its sharp definition appears, demonstrating that some kind of rays, able to produce phosphorescence in glass, are being thrown out from the cathode in straight lines. The properties of these cathode rays are extremely remarkable. They produce heat in any body which obstructs them, and they possess energy, since they will drive round a little windmill placed in their way. They will actually produce so much heat as under favourable conditions will suffice for melting a piece of platinum wire or charring a diamond.

The Cathode Rays and Magnetism. Most interesting of all are the relations of these cathode rays to a magnet, *which deflects them.* The deflection is that which would be expected in the case of negatively-electrified particles travelling along the path of these rays. Says Professor J. J. Thomson, summing up the researches which have since been made on this point: "Thus the cathode rays carry a charge of negative electricity, they are deflected by an electric field as if they were negatively electrified, and are acted on by a magnetic force in just the way this force would act on a negatively-electrified body moving along the path of the rays. There is, therefore, every reason for believing that they are charges of negative electricity in rapid motion, and by measuring the deflection produced by magnetic and electric fields we can determine the velocity with which these particles move and the ratio of the mass of the particle to the charge carried by it."

The Lenard Rays. We cannot here enter at great length into the various properties of the cathode rays. Nevertheless, certain facts concerning them must be noted. It was shown by Hertz that all solids are not entirely opaque to them, and by Professor Lenard that, under certain conditions, the cathode rays can actually be made to pass from the inside of a discharge tube to the air outside. Cathode rays after transmission through solids are now known as Lenard rays. They are really one and the same with the cathode rays. Says Professor Thomson: "The properties of the rays outside the tube resemble in all respects those of cathode rays; they are deflected by a magnet and by an electric field, they ionise the gas through which they pass, and make it a conductor of electricity, and they affect a photographic plate and change the colour of the halide salts of the alkaline metals. As, however, it is convenient to distinguish between cathode rays outside and inside the tube, we shall call the former Lenard rays."

It is interesting to note that Sir William Crookes gave a correct explanation of the cathode rays from the first. He said that they were "streams of negatively-electrified particles projected normally from the cathode with great velocity." Outside this country his explanation was not accepted, but we now know that he was right. In truth, the work done by observers in this country in this new field of physics is incomparably more important than all the work which has been done elsewhere. When we have concluded this subject, we shall have quoted from Crookes, Thomson, Whetham, Soddy, and Strutt. It is in Germany and America that science is appreciated, but the land of Newton and Harvey and Darwin is still pre-eminent in its creation.

Röntgen's Remarkable Discovery. Professor Röntgen was enabled to observe the invisible rays that go by his name, in virtue of the fact that he happened to be keeping some photographic plates, well covered, in the neighbourhood of a very highly exhausted vacuum tube. He then found that these plates looked as if they had been exposed to light. This was well worth looking into. He found that if he used a screen covered with some phosphorescent substance, it began to glow brilliantly under the influence of *something* that emerged from the tube. Further, he found that certain substances obstructed this something while others did not. "He found that if a thick piece of metal were placed between the bulb and the phosphorescent screen a sharp shadow of the metal was cast upon the screen, but that other substances, such as wood and thin pieces of aluminium, cast but slight shadows, showing that the agent which produced the phosphorescence could traverse with considerable freedom bodies which are opaque to ordinary light. He found that as a general rule the greater the density of the substance the greater its opacity to this agent. Thus, while the effect produced by the phosphorescence could pass through the flesh, it was stopped by the bones of the hand, so that if a hand were held between the discharge tube and the phosphorescent screen the outline of the bones was distinctly visible as a shadow cast on the screen: or if a purse containing coins were placed between the tube and the screen the purse itself threw but little shadow, while the coins cast a dark one."

Characters of the X-Rays. Professor Röntgen was worthy of his good fortune, and made the most of it. He showed that the rays move in straight lines, and that on passing from one medium to another they undergo no refraction. Unlike the cathode rays, they are unaffected by a magnet. Professor Thomson says that he has "sent the rays through a magnetic field of about 8,000 lines of force per square centimetre for a distance of about a centimetre without producing any appreciable defect." Many attempts made to polarise the rays failed; and these facts seemed to suggest that the rays must differ fundamentally from those of light. Nevertheless, on certain points they resemble light. Like light they are propagated in straight lines, they feebly stimulate the retina, they affect the photographic plate, they are not deflected by electric or magnetic influence, and so on. On the other hand, the absence of any refraction does not exclude the possibility of their being really identical with light. Professor Thomson points out that, according to any theory of refraction—which we must conceive as dependent upon the ratio between the period of vibration of the refracting body and the period of the vibrations of light "there would be no refraction for light of very small period, and this would also be true if, instead of regular periodic undulations, we have a pulse of electromagnetic disturbance, provided the time taken by light to travel over the thickness of the pulse be small compared with the periods of vibration of the molecules of the refracting substance."

The Distinctive Property of Röntgen Rays. In the year following the discovery, the late Sir George Stokes suggested that perhaps the Röntgen rays differ from ordinary light in that they consist not of trains or series of waves, but of irregular disconnected waves or pulses: "single disturbances, propagated with the same velocity as light, but not followed by a train of waves." Professor Thomson has shown that whenever the cathode rays—or, rather, his corpuscles—strike a solid, intense electromagnetic pulses must be set up. Since this must be so, what can be more probable than that the Röntgen rays, produced under these very conditions, are none other than the pulses which must occur? Very probably, then, Sir George Stokes was right, and the X-rays consist of intermittent ethereal pulses produced by the impact of the negative corpuscles upon the glass —which is proportionately intermittent—and, furthermore, differing from ordinary light in the extreme shortness of their wave length.

At a comparatively early stage in the inquiry it was found that the Röntgen rays vary somewhat according to the conditions under which they are produced. This is an

important matter theoretically, since it suggests, for instance, that there may be a whole series of "notes" of Röntgen rays corresponding to the notes or colours of visible light. Physicians and surgeons also have come to recognise the extreme importance of distinguishing the various kinds of Röntgen rays, since one kind may have a curative effect which is entirely absent from the others. If the vacuum tube has not been exhausted to any very great degree—the gaseous pressure within it, therefore, remaining pretty high—with the consequence that the potential difference between its electrodes is small and the velocity of the corpuscles between them correspondingly low—the Röntgen rays produced outside the tube are called *soft* rays, and have the character that they are very readily absorbed.

Penetrating Power of the Rays. Very different, indeed, is the penetrating power of the rays produced in a tube which is very highly exhausted. In such a tube, where the potential difference between the two electrodes is high, the cathode rays travel with much greater speed, and the variety of the Röntgen rays they then produce are called *hard* rays. Says Professor Thomson: "With a highly exhausted tube and a large induction coil it is possible to get appreciable effects from rays which have passed through sheets of iron or brass several millimetres thick. The penetrating power of the rays thus varies with the pressure in the tube; as the pressure in the tube gradually diminishes, when the discharge is kept running through the tube, the type of discharge proceeding from the tube is continually changing. Not only do different bulbs emit different kinds of rays, but the same bulb may emit, at the same time, rays of different kinds. The property by which it is most convenient to identify a ray is the absorption it suffers when it passes through a certain thickness of aluminium and tinfoil." But, nevertheless, experiments made on this point show that the rays vary among themselves even more than was thought, and, as has before been stated, this question of the difference between various kinds of Röntgen rays is not only one of great physical interest but may also frequently be a matter of life and death.

The Effects of the Rays. Until quite lately it could not be said that the real nature of the Röntgen rays was *proved*, though in all probability they were neither material particles nor longitudinal waves in the ether, as the discoverer himself had suggested, but consisted of transverse ethereal disturbances. But if they were transverse they ought to be polarisable, and until quite lately all attempts to polarise them had failed. The use of tourmaline plates gave no evidence of polarisation. Quite lately, however, another method has been employed, in describing which we may quote from Mr. Strutt, who is the son and heir of Lord Rayleigh, the President of the Royal Society, and affords a conspicuous instance of inherited scientific genius. He has made very important contributions to various aspects of the subject which we are now discussing.

"The rays," says Mr. Strutt, "are allowed to fall on some light substance, such as paper or carbon. Under these circumstances the paper or carbon becomes itself a source of rays—secondary rays as they are called. The amount of secondary radiation in any fixed sideways direction is found to vary, as the vacuum bulb giving out the original rays is made to turn round in such a way as to rotate the beam of rays on itself, without changing its direction. This proves that the beam has a one-sided character, and establishes most satisfactorily that the vibrations must be in a transverse direction; for if the vibrations were longitudinal it is impossible to conceive how turning the beam round could make any difference. Later and more elaborate experiments have shown that this one-sidedness is much more marked in the secondary rays themselves than in the original ones from the bulb."

The Use of the Rays. This must obviously be regarded as conclusively proving that the Röntgen rays are essentially identical with light. If we could show finally that the rays have the same speed as light we might regard our proof of their nature as complete. It has recently been attempted "to compare the speed of the rays with the speed of electric waves travelling along a wire, which is known to be the same as that of light." So far as these experiments have hitherto gone they seem to show that, as might be expected, the velocity of the Röntgen rays is identical with that of light. We may note that M. Blondlot, whose alleged discovery of the N-rays is still under discussion, claimed some two or three years ago to have shown that the Röntgen rays are polarisable and that they move with the velocity of light.

Let us now turn from the purely physical aspect of this study to the question of utility, which, as a matter of fact, has advanced very much more rapidly than the purely scientific question. No sooner had Professor Röntgen demonstrated the fact that he could see his own bones, or rather their shadows, projected by the rays, than the surgeons turned the fact to account. Plainly, this property would be very much to the point if it were applied to broken bones, the position of which it is often very difficult but always very important to ascertain. Nowadays a thoroughly up-to-date surgeon with a perfect equipment and plenty of time not only uses the Röntgen rays in every case of fracture, but, after the fracture has been set, and the bandages and splints and all have been put on, takes another photograph so as to make quite sure that the fragments of the bone are lying in perfect position.

The Enormous Gain to Humanity. The surgeon acts similarly, in the case of dislocations, in the case of bullets, and needles. On this mere point of finding needles the reader can have little idea how many women the discovery of the Röntgen rays has benefited. Furthermore,

it is quite easily possible to see the movements of the heart by means of the Röntgen rays, and this has enabled doctors to confirm the theories formerly held as to the causation of the various sounds produced by the normal and the abnormal heart. Many cases of the disease known as aneurism can also be readily detected by the size of the shadow which the diseased artery throws upon the screen. Furthermore, the early signs of consumption or tuberculosis of the lungs can be detected by the increased opacity which this disease causes to these rays, and some observers are of opinion that the disease can be thus diagnosed sooner than by any other means. Again, there is a large number of different kinds of stone occurring in the body, the presence of which can be detected by the shadow which they cast under these rays—a means of diagnosis which is now of the utmost value in surgery.

The Röntgen Rays and Living Matter. It is a curious circumstance that, so far as can be judged, the X-rays have no deleterious action upon microbes. This is curious, because, as we shall see, they are of very great value indeed in the treatment of various diseases of microbic origin. When the Röntgen rays are allowed to act upon the skin, they cause a number of remarkable changes in time. They very often destroy entirely the roots of the hair, though hitherto it has not been possible to control the production and character of the rays in sufficient degree to justify their use as a substitute for the razor in the case of priests or other persons who are compelled to spend a considerable part of their lives in keeping down a beard which might be arrested for ever by the Röntgen rays. The skin itself is also apt to undergo various changes which may amount either to severe inflammation or even to actual destruction. It is the lamentable fact, also, that the ulcers produced by these rays sometimes become cancerous. Doctors and their assistants, working the Röntgen ray departments of hospitals, are now learning that it is necessary to protect themselves by means of leaden gloves or shields. The most opaque substances of all to the Röntgen rays are platinum, mercury, bismuth, lead, and silver.

The Displacement of the Knife. The public are already familiar with the use of the Röntgen rays in diagnosis, but in quite recent times they have been employed as a means of treatment, and in many cases their use has been followed by the most astonishing, not to say unexpected success. Like ultra-violet light, the Röntgen rays are perfectly effective in curing lupus, but their penetrative power is far greater. In the therapeutic use of ultra-violet light, great importance is attached to the exclusion of as much blood as possible from the area of the skin to be acted upon, for even the thinnest film of blood absorbs these rays. Very different, however, are the Röntgen rays, which will pass right through the body, and thus their range of employment as therapeutic agents is very much greater than that of ultra-violet light. The Röntgen rays will cure deeply-situated cases of lupus against which the Finsen treatment is powerless. Besides this disease, a dozen other diseases of the skin might be named, including notably ringworm and its allies, which are curable, and are now constantly treated, by the Röntgen rays. Much more important is the conquest by this means of one variety of cancer—that known as *rodent ulcer*. It is true that this is by far the least malignant variety of cancer, and the reason why it alone is susceptible to the action of the Röntgen rays is doubtless that it is also the most superficial variety. But rodent ulcer is a common disease, and no words can say how magnificent is the gain involved in the displacement of the knife by these rays in the treatment of this once terrible disease.

Cures by Röntgen Rays. These facts raise questions of the very greatest scientific interest, and more especially when we realise that the rays apparently have no antiseptic action in the ordinary sense. The cures they effect seem to be due to their stimulation of the tissues of the body, and the question we must ask ourselves, without any possibility as yet of answering, is—How do these electromagnetic pulses so affect living matter as to give rise to these consequences? Science will have advanced much further before it is possible to explain these facts in physico-chemical terms.

The rapid advance of the physics of the Röntgen rays has been of great value, of course, as regards their application in what used to be called physic. Notably, it is now being found that when rays of the right kind are employed in sufficient abundance their therapeutic action is very far from being confined to the surface of the body. On the contrary, there are various diseases of the internal organs, most of them responsive to no other kind of treatment, in which great gain results to the patient from the employment of the Röntgen rays. It is nothing short of amazing to contemplate the revolution in many branches both of surgery and of medicine which has been effected in a few short years as a direct consequence of Professor Röntgen's first observation.

The Theory of Radiation. We have now completed our discussion of many various kinds of radiation. We have said all that there is time to say of the rays of ordinary light, the ultra-violet rays, the infra-red rays of radiant heat, the still somewhat dubious N-rays, and the Röntgen rays. The proposition has been submitted that, widely though these differ from one another in respect of their physical properties, and still more widely in respect of their influence upon our senses, yet they are one and all to be regarded, together with many other radiations known and unknown, as fundamentally identical.

For our present purposes, then, we must dismiss the differences between these various kinds of rays, and must consider the extremely difficult subject of radiation in general, recognising that by this term we include radiations visible and invisible.

Radiation and Temperature. This is one of the most complex subjects in the whole of physics, and we can present it merely in outline. More important than any of its details is the recognition by the student that there is, or may be, a general theory of radiation. Perhaps the first fact worthy of being insisted upon is the extreme intimacy of the relation between radiation and temperature. This is of the utmost importance in respect of theory and of equal importance because of the remarkable information which the application of this principle affords us when we turn to the study of the stars. Let us recall for a moment what we have learnt regarding heat. We have seen that heat may be transferred by conduction, by convection, or by radiation; but now we may consider more critically this last process, which we shall find to be fundamentally different from the other two. We know that a radiant body in consequence of its radiation cools. We know also that the bodies which absorb the radiation are heated, but are we entitled to apply the term heat to that which passes between the radiating and the absorbing bodies? The nature of the problem is usually obscured by the language we employ. We describe what passes as *radiant heat.* But the critical reader will have already noticed that there is a fundamental distinction between this radiant heat which, according to our latest studies, is none other than an electromagnetic phenomenon of the ether, and the ordinary heat, which consists, as we have said, of a vibration of certain material molecules

We may utilise the words of Professor Tait in proof that radiant heat is not really heat at all, though it may be in some way caused by heat and in some way cause heat. "When a piece of clear ice is cut into the form of a large burning-glass, it can be employed to inflame timber by concentrating the sun's rays, and the lens does the work nearly as rapidly as if it had been made of glass. It is certainly not what we ordinarily call heat which can be transmitted under conditions like these. Radiation is undoubtedly a transference of energy, which was in the form commonly called heat in the radiating body, and becomes heat in a body which absorbs it; but it is transformed, as it leaves the first body, and retransformed when it is absorbed by the second."

Visible and Invisible Light. The reader will understand that the term "radiating" in the above quotation includes all luminous bodies. We are speaking now not merely of radiant heat, but of light as well. This we shall see by another quotation showing the absolute continuity between the visible and the invisible. "The more intensely a cannon-ball is heated the more luminous does it become, and also the more nearly white is the light which it gives out. So well is this known that in almost all forms of civilised speech there are terms corresponding to our 'red-hot,' 'white-hot,' etc. As another instance, suppose a powerful electric current is made to pass through a stout iron wire. The wire becomes gradually hotter, up to a certain point, at which the loss by radiation and convection just balances the gain of heat by electric resistance. And as it becomes hotter the amount of its radiation increases, till at a definite temperature it becomes just visible in the dark by red rays of low refrangibility. As it becomes still hotter, the whole radiation increases; the red rays formerly given off become more luminous, and are joined by others of higher refrangibility. This process goes on, the whole amount of radiation still increasing, each kind of visible light becoming more intense, and new rays of light of higher refrangibility coming in, until the whole becomes white—that is, gives off all the more efficient kinds of visible light in much the same relative proportion as that in which they exist in sunlight. When the circuit is broken, exactly the same phenomena occur in the reverse order, the various kinds of light disappearing later as their refrangibility is less. But the radiation continues, growing weaker every instant, even after the whole is dark."

This illustration affords one more proof of the continuity between the visible and the invisible, but it also constitutes an illustration of the proposition that there is a definite relation between temperature and radiation. If we translate what happens into the best symbols that we know, we must imagine that as the molecules of the wire become hotter and the character of their vibrations alters, so they give rise to ethereal waves of shorter and shorter wave lengths and greater and greater frequency.

The Laws of Radiation. The whole of radiation, then, is one phenomenon, and to have discovered this constitutes a great triumph of the mind over the imperfections of our senses. Let us now consider what general propositions can be advanced beside that of the relation between temperature and radiation. Nearly half a century ago Balfour Stewart showed "the absolute uniformity, qualitative as well as quantitative, of the radiation at all points and in all directions within an enclosure impervious to heat when thermal equilibrium has once been arrived at." He showed, by many experiments and observations, that radiation and absorption rigorously compensate each other, not merely in quantity but in quality also, so that a body which is specially absorptive of one particular ray is in the same proportion specially radiative of the same ray, its temperature being the same in both cases. Stewart's final statement was that "at any temperature a body's radiation is exactly the same, both as to quality and quantity, as that of its absorption from the radiation of a black body at the same temperature."

The last proposition shows that Stewart worked first at radiant heat, but his propositions were true alike of light. In short, they are true of radiation in general. Balfour Stewart's work was, indeed, a confirmation and extension of the very important idea first enunciated by Prévost in 1791, and called by him the *Law of Exchanges.*

Continued

THE TREATMENT OF WATER

Impurities in Water. Water Filtration. Hard Water and Water Softening. Varieties of Water Filters and their Principles. Domestic Filters

continued from page 4029

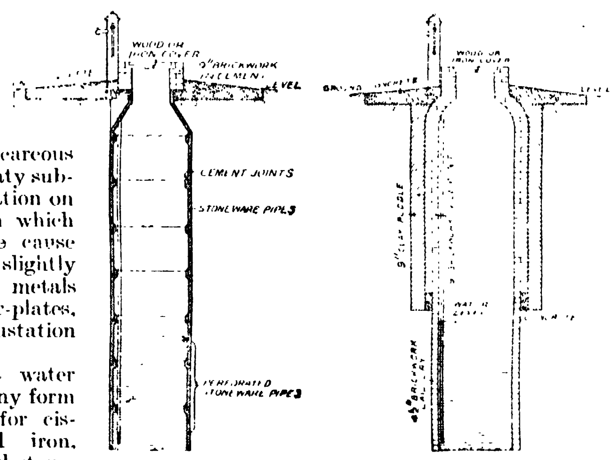
By Professor HENRY ROBINSON

Wells for Cottages. At the Conference on "Water Supplies and River Pollution," held by the Royal Sanitary Institute in London in 1901, the question of the water supply to isolated cottages and small groups of cottages was brought forward by Dr. Thresh, the Medical Officer of Health, Essex County Council, and he showed two of the simplest methods of well construction that had been adopted to ensure the exclusion of pollution from the well by making the first 12 ft. or so watertight. Figs. 5 and 6 are illustrations of these wells.

Impurities in Water. Water contains mineral impurities in the form of soluble salts which have been absorbed during its flow over or through the various geological formations from which the supply is obtained. Where the water has come into contact with metalliferous deposits containing salts of lead or copper it must be regarded as dangerous to health.

Soft water, being free from calcareous matter, dissolves peaty substances from vegetation on the watershed from which it flows, and these cause the water to be slightly acid and to attack metals such as lead, boiler-plates, and to form incrustation thereon.

For storing soft water in houses, lead in any form must be avoided for cisterns. Enamelled iron, porcelain, enamelled stoneware, and slate, are used for cisterns to hold soft water. Iron is sometimes used, having a protective coating of quick-drying asphalte varnish.



5. 6.

TYPES OF SIMPLE COTTAGE WELLS

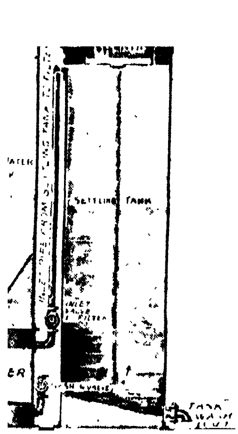
The effect of storing polluted water in copper vessels has attracted attention of late years owing to its having been observed that in India, during a cholera epidemic, one district escaped. It was found that the people there stored water in copper vessels and were immune, although the condition of the water was the same as in the neighbouring districts which were affected. Recent research has shown that copper is destructive of pathogenic organisms.

Impure water can be sterilised by applying to it electrolysed salt water. By passing a current of electricity at a low voltage through a saline solution a fluid is produced which has an intensely sterilising effect, and destroys all bacteria. The writer has carried out works where this was successfully accomplished, a very foul sewage-polluted water being freed from all micro-organisms by passing into the flowing water automatically an amount of the sterilising fluid called *electrozone*.

Taking Samples of Water. Samples of water for chemical and bacteriological examination require to be taken in a definite way. The bottle, generally a Winchester quart, is carefully washed with distilled water and exposed in an oven to a high temperature to sterilise it. In taking the sample the bottle should be quite immersed before the stopper is removed, and it should be replaced under the water when the bottle is full, so as to prevent any surface scum from entering. If the sample is from a shallow stream or well, care must be taken not to disturb the sediment. The top of the bottle should have a descriptive label attached to it, the stopper having been replaced and securely closed, so that nothing can gain access to the bottle until it is consigned to the care of the analyst.

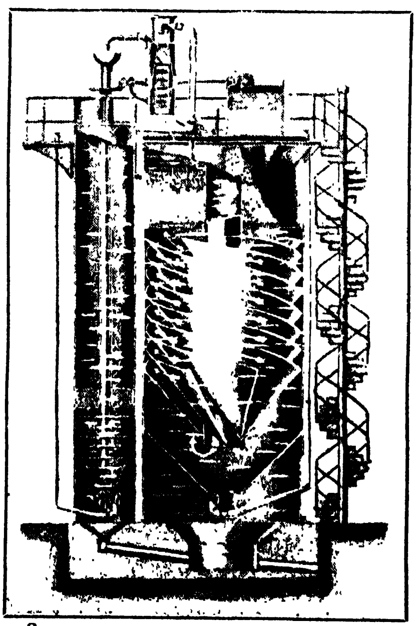
Hardness of Water. Hardness in water is caused by the presence of carbonates, sulphates and nitrates of lime and magnesia. Hardness is either temporary or permanent. It is called temporary if the carbonates are present, as they are not to any practical degree soluble in water, but they are in the carbonic acid, which is in solution, and which can be driven off by boiling the water, when the carbonates are precipitated and the water is made soft. To soften water on a large scale, caustic lime as lime-water is added to the water, and, combining with the carbonic acid, forms carbonate of lime, which precipitates. The term hardness implies that a certain quantity of soap has to be decomposed before a lather can be formed. When water is said to have a certain number of degrees of hardness, it is meant that a gallon of water will curdle and precipitate as much soap as would be

precipitated by a gallon of pure soft water in which that number of grains of carbonate of lime had been dissolved. Water of 12 degrees of hardness will precipitate as much soap as pure water would to which 12 grains of carbonate of lime had been added per gallon. Lime alone will reduce the degree of hardness from 18 degrees to 4 degrees, and will effect a saving in the use of soda and soap. A hundredweight of quicklime, costing 8d. or 9d., is productive of softening represented by 4¾ cwt. of carbonate of soda and 20¼ cwt. of soap. The writer carried out works to soften very hard water at a large public institution, and it was found that the saving effected in various ways more than covered the repayment of the loan for the works, besides the attendant comfort and convenience of the people.



7. CRITON WATER SOFTENER

Deposits in Boilers. Hard water causes deposits in boilers, which are most undesirable as the scale formed leads to unequal heating of the metal and the risk of explosions. The writer applied a simple softening arrangement to water of 14·5 degrees of hardness at an installation of boilers, and reduced the hardness to about 4 degrees, using a pound of lime to a thousand gallons of water, incrustation being prevented.



8. SECTION OF DESRUMANX WATER SOFTENER

Water Softening. Permanent hardness is caused by the water containing certain salts in solution, the chief of which are calcium chloride, magnesium sulphate and chloride, and sulphate of lime. These can be removed by adding carbonate of soda to the water in proper proportions, and storing the same in suitable chambers, where deposition takes place. Several mechanical arrangements have been devised to accomplish this. One is called the Criton Water Softener [7], made by the Pulsometer Engineering Co.

The quantities of the reagents are measured by filling vessels of given capacities adjusted to give the required proportion of reagents to the hard water.

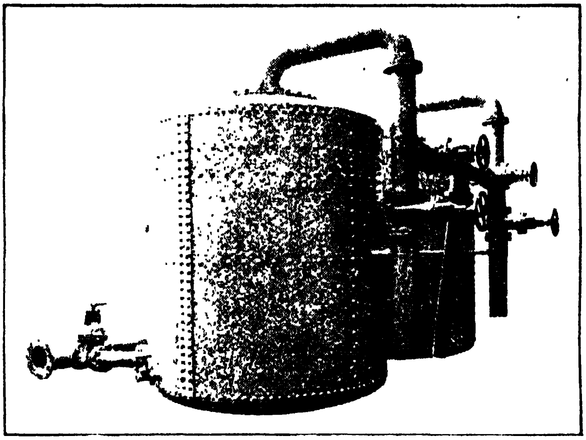
The hard water is admitted to a tank divided by a partition into two unequal portions: the larger of these, which contains a syphon, is called the *syphon-tank*, and the smaller the *measurer*. The top of the partition is two inches below the level at which the syphon begins to discharge. When the level of the water in both compartments has reached the discharge point, the syphon automatically discharges the contents of the syphon-tank into the mixer, leaving the other compartment brim full. In the syphon-tank is a float, which, as it descends, lifts, by means of a lever, a valve at the bottom of the measurer, and permits the accurately measured quantity of water to run into the limer, displacing an equal quantity of clear lime-water, which overflows into the mixer. During its passage upwards in the limer the water passes through a bed of slaked lime, and on reaching the top has become saturated lime-water. The bed of lime is kept stirred up by an agitator worked from the float of the syphon-tank.

Attention was called in the "Public Health Engineer" for September, 1905, to an apparatus for softening water called the Desrumanx, which deserves mention.

This apparatus, as will be seen from the section shown in **8**, consists of two cylindrical tanks, the one on the left-hand side of illustration being the lime saturator for making lime-water, and that on the right-hand side being the decanter, in which the reagents are mixed with the water to be softened, and the clear soft water decanted and filtered ready for use.

Filtering. For filtering water on a large scale for public supply the form of filter employed in the past consists of a layer of clean, sharp sand, about $\frac{1}{50}$ in. average size, from two to four feet in thickness,

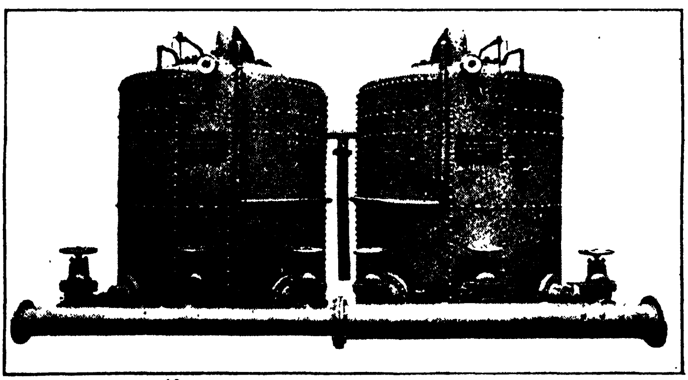
beneath which is a thinner layer, about six inches, of fine gravel, with a layer of coarse gravel underneath. A series of small drain-pipes at the bottom carries the water, which passes downwards, to the main-collecting outlet drain or drains. At the farthest ends of these, drains from the outlet pipes are carried up the walls of the filter-bed to the surface, to enable the air in the bed to escape when the filter is being filled. The usual rate of filtration varies with the conditions of supply and demand, but that which has been adopted for the supply of London is about 400 gallon to 500 gallons per sq. yd, per 24 hours, the rate being measured by a meter, either at the inlet or outlet. The head of water on the top of the filtering material is regulated to about two feet. The clear water is conveyed to a tank, which should be roofed in if it is in the open, and placed at a level to enable it to receive the water from the filter-bed. When the cistern is quite full and the bed emptied for clearing purposes, the head can force water upwards through the bed to remove impurities. To obtain a uniform rate of filtration through the whole of the bed, which is an important matter, the length, number, and size of the drains have to be arranged to meet the variation in pressure in the drains, which is least towards the outlet.



9. CANDY'S WATER FILTER AT HASTINGS

The rate of percolation through the bed should be regulated to prevent its being waterlogged, as the removal of organic matter in the water is not by mechanical but by bacterial agency, and the micro-organisms that accomplish this are aerobic, requiring air. The foregoing system of filtration has been termed the *slow sand* method.

It was at one time thought that the efficiency of a sand filter, as regards the removal of bacteria from the water, depended on the maintenance of the surface film, which is formed by the collection of vegetable and organic matters floating in the water before it is passed over the filter. This view has been shown to be incorrect by the observations which were made by Mr. Clark, the chief chemist to the Massachusetts Board of Health, and communicated in 1901 to the Institution of Civil Engineers by Mr. Rutter, who was connected with one of the large stations for the supply of London. He carried out a plan by which the surface film was systematically disturbed on a large area of open filters dealing with 25,000,000 gallons of water per day.



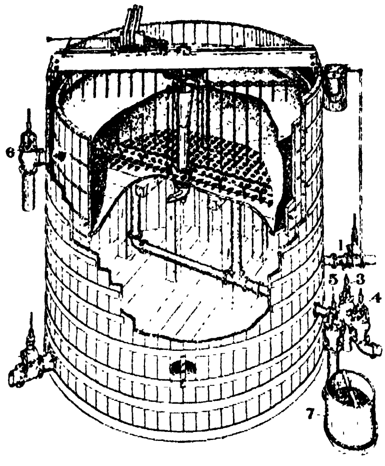
10. FRONT VIEW OF CANDY FILTERS

Candy's Water Filter. Candy's system of water purification consists in forcing air under pressure into the water, and subsequently passing the aerated water through a filtering medium in which "polarite" plays a part in conjunction with sand. The combined effects of aeration and filtration have been found to yield an excellent water at Hastings and St. Leonards. It has been characterised by the waterworks' engineer there as being "colourless, sparkling, and of the highest organic purity," and he states that the system is "a most satisfactory and economical method of purification." The material called *polarite* is an artificial one, prepared specially for use in sewage and water filters, and being insoluble, and having an oxidising property, has been found useful in this connection.

Fig. **9** shows filters, 15 ft. in diameter, at the Hastings Waterworks, for dealing with 2,000,000 gallons a day. Figures **10** and **11** show a front and end view of two out of a battery at Cardiff. The cost of cleansing and working, including upkeep, is stated to be about 1d. per 50,000 gallons for a town's supply of over 1,000,000 gallons a day.

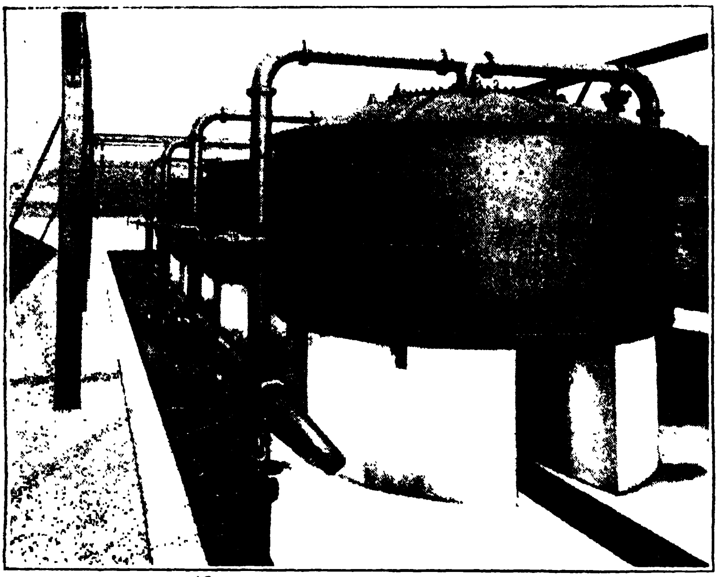
Sterilisation of Water. The sterilisation of water in the field was the subject of

an inspection by Mr. Arnold-Forster (then Secretary of State for War), at Millbank Barracks, in August, 1905, of several apparatus for that purpose. They were classed under three heads. First, chemical methods of sterilisation by the employment of permanganate of potash, bisulphate of soda, alum, sulphate of copper, bromine, iodine, and chlorine. The second class of apparatus employed filtration, and the third class relied upon boiling the water. The last is advocated by some authorities for army purposes, as the rough treatment to which filters would inevitably be exposed in the field might lead to the unnoticed breakage of a candle, whereby the water passing through it would be unfiltered, and the consumers would suffer accordingly.



11 JEWEL GRAVITY FILTER

The "Jewel" Filter. The system of water purification that has been introduced by the Jewel Export Filter Company (of America) has been so successful that it deserves mention.



12. END VIEW OF CANDY FILTERS

It is based on the application of some harmless soluble salt, such as sulphate of alumina, as a coagulant to the water, after which sedimentation and filtration is effected in specially arranged tanks, either open, when they are termed *gravity* filters, or closed, when they are called *pressure* filters. The writer has before him the results of many investigations of the treatment of water by these filters, and it appears that they possess advantages over the ordinary sand filters, called by the Americans the *slow sand* system, while the Jewel filter is termed the *quick sand* filter.

In comparison with slow sand filters, it is claimed that rapid filters possess, among other advantages, the capacity to treat very turbid waters and to remove a large percentage of colour.

Figs. 11 and 15 show a Jewel "gravity" filter with and without a subsidence basin, and 13 shows a "pressure" filter.

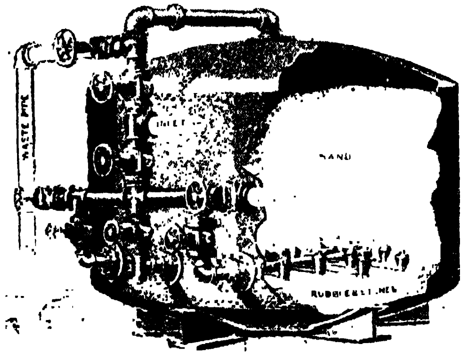
The addition of sulphate of alumina to the water results in the formation of a gelatinous insoluble coagulum of considerable bulk, and of greater specific gravity than the suspended particles present in the water. The natural precipitation of this coagulum brings about the aggregation and deposit of the greater part of the suspended matter. By this means from 40 to 75 per cent. of both suspended matter and bacteria can be removed from the water before it reaches the filter bed.

The filters consist of wood, iron, steel, or concrete tanks, containing a bed of carefully-graded and selected sand of uniform size, supported by a special screen system. To these are connected the necessary influent, effluent, wash-water, and sewer-pipes.

The rate of filtration may be varied from 1,600 imperial gallons to 3,200 imperial gallons per foot per diem, or from 70,000,000 gallons to 140,000,000 gallons per acre per diem. The maintenance of this rate of flow requires a large filtering head, varying from 6 ft. to 14 ft. A relatively small head of water is carried over the sand bed, as it has been found that a negative head gives better results. This relatively high filtering head results in the compacting of the sand bed. On this bed the precipitation and straining out of the coagulated material causes the rapid formation of a gelatinous and sticky film. This film retains the greater part of the bacteria and suspended matter.

When the filtering film has become too thick and dirty for filtration to be economically continued the sand bed is washed. This is done

by reversing the flow of water; a current, preferably of filtered water, is forced upwards with



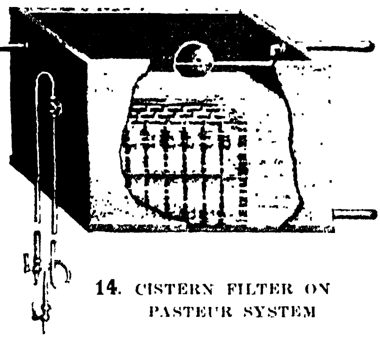
13. JEWEL PRESSURE FILTER

considerable velocity through the screen system and sand bed, wholly removing the deposited film and accumulated dirt, and restoring the sand bed throughout its entire depth to a state of purity. All sand grains coming into contact with water containing organic matter will, in course of time, collect an organic coating, particularly if the water passing through them carries with it any oil or greasy matter. The grains then become smooth and slippery, and deteriorate in filtering efficiency. This shiny organic coating surrounding the filtering sand is easily removed in a few hours without removing the sand from the filter tanks.

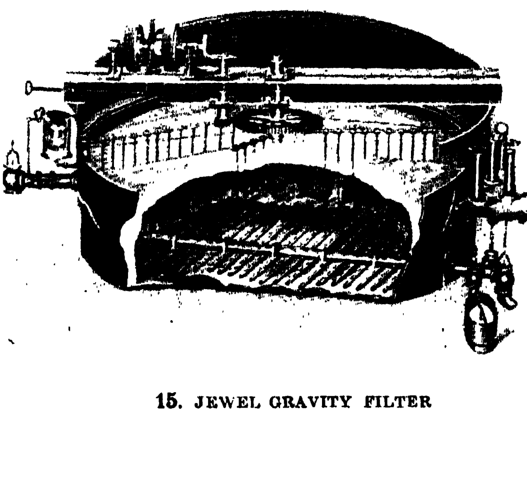
As in slow sand filters, it is most important that the rate of filtration should be perfectly uniform, and that the pressure should be gradually and uniformly increased as the bed becomes dirty and less porous. To secure this, all filters are provided with a patent automatic controller that maintains a perfectly uniform rate of flow under all conditions. They are also provided with loss of head gauges, that show at once the regularity of the increase of the filtering head. Each filter is also fitted with a valve connected to the waste-water main, so that, if desired, the first filtered water can be run to waste. Special sample draw-off cocks are provided, and the operator has at all times control of each individual filter and a knowledge of its condition.

Pressure Filters. For domestic and manufacturing purposes, and in some cases for municipal supplies, the pressure type of filter will be frequently found to be more convenient than the gravity type. It requires no machinery for agitating the sand bed. It occupies less space, and is sometimes more economical, as in many cases it is possible, by using a pressure filter, to avoid double pumping. It also saves the additional pumping of water for washing the filters. Many patterns of pressure filters have been constructed, but the New York pattern, as shown in the illustration [13], has been proved to be the most satisfactory and convenient. The filter bed consists of carefully graded sand, supported by a screen system, as in the gravity type; but the whole is enclosed in an iron or steel cylinder tested to 100 lb. pressure. The bed is washed by a reversal of the flow, and, as in the gravity pattern, the full volume of wash water can be directed into either the whole or separate sections of the filter bed.

The Jewel system of filtering water was adopted in connection with the Alexandria waterworks, and the completion of the filters was inaugurated by the Khedive in October, 1905. Before the system was introduced a most exhaustive series of experiments was made, and the chief engineer and the sanitary inspector reported to the municipal council in July, 1905, the completion of the entire works. Their report states that in the case of the bacterial efficiency of the new filters, from numerous analyses which have been made, it is especially shown that the removal of the microbes from the raw water by the process of subsidence and filtration has always been very satisfactory. Even during the most difficult periods of filtration, when the efficiency was at its worst—that is to say, during the first half hour after the washing of the filter—it was never below 99 per cent. It takes but five minutes to wash a filter, and yet within fifteen to twenty minutes after the beginning of a new period of work the filter again acquires its normal efficiency. It should be especially noted that the filters have worked under very difficult conditions owing



14. CISTERN FILTER ON PASTEUR SYSTEM

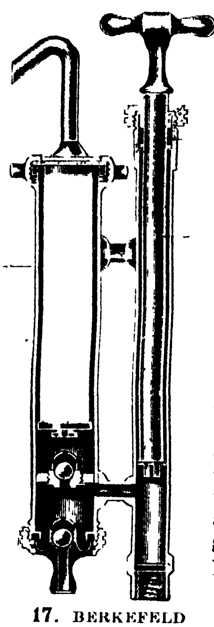


15. JEWEL GRAVITY FILTER

to the presence of numerous algæ in the raw water (season of green water). Notwithstanding this the results of filtration continued to be satisfactory. To cite but one example, the number of bacteria, always entirely harmless in the filtered water, was on July 8th but 22 per cent., while the raw water contained about 8,000 per cent. Upon the whole, it is stated that the new process of filtration produced a water perfectly limpid, clear, and practically free from the microbes of the raw water.

Oxidium. Reference has been made to the results obtained by using polarite in filters. A new filtering material employed by Mr. Candy, called "Oxidium," has recently been brought out, having properties similar to those of spongy platinum. It has been the subject of experiment by Dr. Thresh in comparison with polarite, and he states that oxidium reduced the free ammonia 90 per cent., and the organic ammonia 50 per cent., more than polarite.

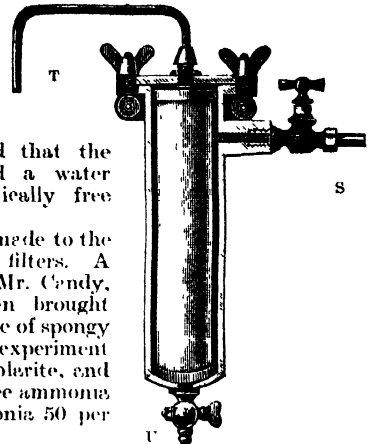
Domestic Filters. The examination of water that had been passed through the various forms of domestic filters that were much in vogue years ago was confined to chemical analysis only, and the dangers attending the employment of a filter that had become foul with use were not realised. When bacteriological tests enabled the presence of micro-organisms to be detected the whole aspect of the matter became changed. Filters which had previously been used for a long time, until some discoloration of the water, bad odour, or unsatisfactory chemical analysis caused them to be sent back to the makers to be cleaned, were no longer regarded as affording safety. Many distinguished bacteriologists examined domestic filters, and their published opinions showed that the majority of the old types of filters cultivated, rather than destroyed, disease germs.



17. BERKEFELD PUMP FILTER

There are a variety of filters made on the principle discovered by Pasteur and Chamberland of employing particular earths which arrest disease germs. Fig. 14 shows a cistern filter exposed through the broken side of the cistern.

It consists of a galvanised iron frame with one or more rows of filter-tubes, connected by strong elastic collectors, and carried in a galvanised wrought-iron cage. The collectors are connected with a main collector, of which the end projects through the cistern, and is connected to a syphon pipe furnished with cocks for permitting the flow of filtered water and for expelling the air on starting. The quantity delivered varies from 100 gallons to 400 gallons a day, according to the number of rows of tubes. If a single tube only is used, as shown by the illustration of the service filter [16], about 8 gallons a day would be the supply, with a water pressure of 30 lb. per sq. in.



16. BERKEFELD DOMESTIC FILTER

The Berkefeld Filter. The Berkefeld Filter is an excellent one, effecting the destruction of disease germs. The filtering medium is in the form of porous hollow cylinders of various sizes, made of what is described as kieselguhr, an infusorial or silicious earth, consisting of the fossilised skeletons of diatoms. The makers prefer the filter to be used with water under pressure. Fig. 16 shows a filter of the H type, for ordinary house use. S is the inlet tap, T is the filtered water outlet, and U is the flushing tap.

A combination of the Berkefeld filter and pump is shown in 17, called the N type. This has been largely used by travellers, military men, and others who have to obtain their water from sources which, if used unfiltered, would be dangerous to health.

The filtering cylinders require periodical cleaning and sterilising in order to restore their original filtering capacity. As all the impurities are collected on the outside of the cylinder, gradually producing a slimy coating, all that is required is to remove the cylinder carefully from the casing, and while holding it under a tap to brush it gently with a piece of loofah, supplied for this purpose with each filter, or with a clean brush, which must not be too hard. Great care must be taken that no soap or other greasy matter comes into contact with the filtering cylinders. Complete sterilisation can be obtained by placing the cylinder, after been cleansed by brushing, in a clean vessel with cold or tepid water, and then boiling for an hour. After having been boiled the cylinder must be allowed to cool again.

Continued

FRANCE IN THE MIDDLE AGES

Continued from page 3999

An Important Epoch in the History of France. Louis IX. and England. The Famous Reign of Francis I. St. Bartholomew's Day

By JUSTIN McCARTHY

MEANTIME, continental Europe was dividing and subdividing, distributing and redistributing itself into distinct states, which were at this time settling down into something like the lines of demarcation they have since maintained. Many of these lines were afterwards broken into and confused, and realms which were then formed afterwards became blended by circumstances with realms of superior strength. But even at the time when the Wars of the Roses came to an end the peoples of the European continent were beginning to form themselves into those states, monarchical or republican – for the most part monarchical—in which they are represented in the maps of the present time.

The principle of nationality counted for little in the formation of these early kingdoms and republics. Every rising state in Europe, and in many other parts of the world, went in for a policy of conquest and annexation, and did not trouble to ascertain whether the newly-annexed region could be made a contented and adhering part of the power that had conquered it. Even in Europe many different nationalities were now made part of one state, and, again, part of another; continued for generations and even for centuries to be parts of the dominions of each successive conqueror; then at length broke away, and, by the force of victorious resistance, established themselves as independent nations.

The House of Capet. With the reign of Hugh Capet began the monarchy of France as it lasted until the French Revolution. Louis le Gros, who reigned from 1108 to 1137, did much to improve the condition of the country; he regulated the feudal system, abolished serfdom on his own estates, and founded the free burgher class. Philipe Auguste, who came to the throne in 1180, took an active part in the Crusades. There were many wars in his reign; he recovered Normandy, Maine, Touraine, and Poitou from King John of England, and defeated the Germans in the famous battle of Bouvines. He made many improvements in the administration of the laws, created a Chamber of Peers (six ecclesiastical and six secular), and from his reign date the University of Paris, the Louvre, and other famous institutions. Many of the improvements in civil government initiated by him were continued by his son Louis VIII., and in 1226 his grandson Louis IX. succeeded.

Louis IX., known as St. Louis, was born on April 25th, 1215. He became a powerful sovereign, and by his victories compelled Henry III. of England to recognise French sovereignty in some parts of France which had, up to that time, been under foreign rule. He suffered from a very dangerous illness, and during the malady made a vow that in the event of his restoration to health he would go out to the East as a Crusader.

Louis IX. and His Reign. He recovered, and appointing his mother, Blanche of Castile, regent of the kingdom in his absence, led an army of 40,000 men to Egypt. There at first he met with success and captured Damietta, but it was not long before he suffered a defeat. He was himself taken prisoner, and only released upon paying a large ransom. He did not, however, give up his crusading task, but went with the remains of his army to Acre in Palestine, and remained in that region until the death of his mother compelled him to return to France. There he showed himself an able and enlightened ruler, and by the "Pragmatic Sanction" determined the relations of the French Church with the Papal authority.

The Pragmatic Sanction was the title given to the ordinances of the Kings of France which arranged the settlement of Church and State affairs. Louis authorised the founding of the Sorbonne, a society of ecclesiastics at Paris formed by Robert de Sorbonne, devoted to teaching the poor and the study of theology. He instituted throughout the French provinces Royal Courts of Justice, or Parliaments, for the administration of the laws, and was the author of an entirely new system designed to introduce equal legislation for all classes. In 1270 he started on a fresh crusade in the East which cost him his life; he died in the August of that year of the plague at Tunis. In 1297 Louis was canonised by Pope Boniface VIII. He was unquestionably a man of noble purpose, of great ability, with views of equitable government much in advance of his age, and his reign marks an important epoch in the history of France.

The States General Instituted. His son, Philip III., who succeeded him in 1270, was the first to issue titles of nobility conferred by letters patent. He also restored Valois and other parts of France to the French Crown. Philip IV., called Le Bel, who came to the throne in 1285, tried to secure support for himself against the prelates and the territorial nobility by giving prominence to the burgher section of the community. Under him the "States General" was instituted, a representative assembly in which the farming and trading classes held a place and became the "Tiers Etat" of the nation, the nobles and the clergy representing the other two classes. In his reign the transfer of the Papal Chair to Avignon brought the Popes under the influence of the French Court for many years. By his three sons

and successors—Louis X., Philip V., and Charles IV.—the rule of the French sovereigns was extended and also much strengthened. Philip VI., the first king of the House of Valois, succeeded in 1328 by right of the Salic Law, which forbade women to inherit the crown in France.

In his reign and those of his successors, John and Charles V., Le Sage, France was much engaged in wars with England, which were productive to France of nothing but disorder, enormous taxation, and wide-spreading arbitrary conscription. The final defeat by the English at the Battle of Agincourt, in 1415, occurred during the reign of Charles VI., who came to the throne in 1380. This king became insane and was succeeded by his son Charles VII., Le Victorieux, the Dauphin who was crowned at Rheims by Joan of Arc in 1422. The only remarkable event of his reign, apart from this, was that he obtained from the States General a regular allotment of taxes for the maintenance of a paid army to keep in check the mercenaries and marauders who pillaged the country.

The Founder of Three Universities. Louis XI., the eldest son of Charles VII., who had made efforts to obtain the throne during the lifetime of his father and had then escaped for a time into Burgundy, succeeded in 1461. His reign was full of struggles with Charles the Bold, Duke of Burgundy, and Louis finally made a treaty by means of which some portions of Burgundy were given over to France. During his reign there were wars between France and Austria, and Louis also recovered Maine, Anjou, and Provence. Louis XI. had some good qualities as a man, but few indeed as a sovereign. He loved art, letters, and science, and was the founder of three universities. He increased the number and the power of the Parliaments, not from any enlightened appreciation of the representative principle, but to secure for himself a better defence against some of his feudal vassals. He passed his later years in abject misery caused by his morbid terror of death, and he died at last on August 30th, 1483.

The direct succession of the House of Valois came to an end with the reign of his successor, Charles VIII., who by his marriage with Anne of Brittany secured that powerful state to the Crown of France.

Louis XII., called Le Père du Peuple, was the only representative of the Valois-Orleans family. His reign on the whole tended to strengthen the position of the Crown in France, while it also helped to promote the improvement in the condition of the people.

Francis I. Louis was succeeded in 1515 by Francis I., of the Valois-Angoulême branch, who, as well as Charles VIII., wasted the resources of the state in vain attempts to establish a claim to Lombardy. He had four wars with Charles V. of Spain for the possession of Burgundy and Italy. He was made prisoner at the Battle of Pavia and taken to Madrid. In 1544 he made good his claim to Burgundy, but had to renounce Italy. His reign is famous for the beginning of the Renaissance and of the Protestant Reformation. He strengthened the power of the monarchy and subordinated the power of the clergy to that of the Crown. An ally of the Protestant Princes of Germany and of Henry VIII. of England, he was himself a Catholic.

He was succeeded in 1547 by Henry II., who regained Calais for France. In the reign of Francis II.—1559 to 1560—the House of Guise, a great Catholic family, became the most powerful in the State.

St. Bartholomew's Day. The history of France during the reigns of Charles IX. and Henry III. was little more than a continuation of the struggles between the Catholics and the Protestants. These amounted to civil wars, fierce and furious, and into them were imported the services of Spaniards, sent by the Duke of Alva, of Catholic Germans and Italian troops from Rome. August 24th, 1572, will always be remembered as the date of the Massacre of Protestants on St. Bartholomew's Day, which was generally believed to have been instigated, if not actually ordered, by Charles IX. Many thousands of Protestants were put to death. The King received a letter from Philip II. of Spain assuring him that "in furthering thus the affairs of God, you are furthering your own still more." The massacre had not, however, any of the consequences that Philip anticipated. The Calvinist party, then strong in France, was made stronger by persecution, and at once took up arms. A new civil war began, and was only brought to an end by the settlement at La Rochelle.

The Holy League. Charles IX. was succeeded by his brother, Henry III., who was born on September 19th, 1551. He contributed to the efforts to suppress the Huguenots by military force, and he even took a share in the Massacre of St. Bartholomew. Henry was, both in public and private life, a man of fickle and uncertain temper. He was not even a genuine fanatic, for he was ready to support the Huguenots, or to persecute them, according as advantage to himself could come from either course. His character was weak and dissolute, and he was, like his brother Charles IX., much under the influence of his mother, Catherine de Medici. The Duke of Guise, one of the most powerful nobles of that time, formed a league, known as the Holy League, to maintain the supremacy of the Catholics in France, and also to support the claims of the Guise family to the succession to the throne. Guise, while besieging Orleans, was assassinated by a Huguenot fanatic. This aroused the Catholic party to fury against the Huguenots, whom they regarded as instigators, or at least abettors, of the crime. Henry III. became an ally of Henry of Navarre, and they joined in leading an army on Paris.

Henry III., the last of the House of Valois, was stabbed on August 1st, 1589, by Jacques Clement, a Dominican friar, and he died the following day, after having designated Henry of Navarre as his successor. Henry of Navarre thus became King of France and of Navarre.

Continued

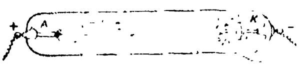
Continued from page 4021

ELECTRONS

Electric Discharges in Gases. Crookes' Tubes. Kathode Rays. Röntgen's Rays. Radium and its Emanations. Radio-activity

By Professor SILVANUS P. THOMPSON

Electrons in Gaseous Discharges. In the last article some elementary facts were given in substantiation of the modern view that electricity itself consists of definite atomic quantities called *electrons*. The greater part of modern knowledge of electrons has, however, been acquired by the study of electric discharges in gases, particularly in vacuum tubes from which the air has been more or less pumped out. Suppose a glass tube [253] to have a pair of platinum electrodes sealed into its ends, and to be partially exhausted by means of an air pump. Let an electric discharge be sent through it by means of an influence machine or an induction coil. At first thin sparks flash through it; but as the exhaustion proceeds the whole tube is filled with a luminous cloud which, at a certain stage, breaks up, as shown in the figure. Near the anode, A, the column of luminous gas is broken up into flickering striations, then comes a dark space, while the kathode, K, is seen to be surrounded by another luminous cloud, chiefly in front of its surface, but separated from it by a second dark space or non-luminous layer. If a mercurial air pump is used so as to produce a very high vacuum, this effect is further modified as follows. The positive cloud retreats towards the anode and disappears. The dark layer around the kathode widens and drives the surrounding cloud away. With still higher exhaustion the dark space expands until it reaches the glass walls of the tube, which then shine with a yellow-green phosphorescent light. It was found by Crookes that this dark beam consists of something which he called *radiant matter*, shot off in straight lines from the surface of the kathode; and that if this dark beam of radiant matter is intercepted by any obstacle, a shadow of that obstacle will be cast on the glass wall of the tube at the opposite end. Fig. **254** shows a Crookes tube, in which a metal cross, J, has been erected. The anode, A, may be set anywhere in the tube. From the kathode, K, are shot out these *kathode rays*, or flights of radiant matter.



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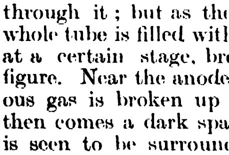
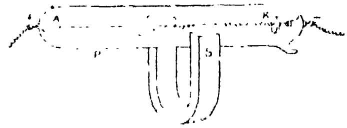


254

Kathode Rays. We now know that these rays consist of negatively-electrified corpuscles, or electrons, driven with an immense velocity. They bombard the walls of the tube and make it shine. If they are concentrated (by making the kathode surface concave) on a bit of metal, they heat it. They can drive around the vanes of a little mill if such be placed in the tube. Kathode rays can be acted upon by a magnet. If, as in **255**, a narrow stream of radiant matter from a kathode is allowed to pass through a hole in a diaphragm, and a magnet is placed near the tube, the stream is observed to be deflected in a curve by the magnetic field, and causes a bright phosphorescent patch to appear when it touches the glass at P. The direction of the deflection shows the stream to be negatively electrified; for negative corpuscles flying from K towards P are electrically the equivalent of a (positive) current flowing from P towards K. According to the researches of Professor J. J. Thomson and others these flying negative electrons move with a velocity somewhat less than that of light, and act as though they were bodies having each a mass about $\frac{1}{1000}$ part as great as that of the atom of hydrogen. They cannot possibly be atoms or ions, because their energy is far smaller than that of atoms would be if flying at the same enormous speed. Moreover, it makes no difference to them what kind of gas was in the tube to begin with, or what metal is used as kathode; the kathode rays are independent of the kind of matter present. The kathode rays possess peculiar penetrating powers. Though they are stopped by a thin wall of glass, they can pass through a thin sheet of aluminium which is quite opaque to light. There are several other kinds of rays produced in vacuum tubes. One of these, known as diakathode rays or canal rays, consists of positive electrons moving much more slowly, and having each a mass about the same as that of a hydrogen atom. They are slightly deflected by a magnet, and in the opposite direction from the kathode rays. They produce a different kind of phosphorescence, and can cast shadows.



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Gaseous Conductivity. All gases in their ordinary state are non-conductors. To send any electricity at all through ordinary air, even across a gap of $\frac{1}{1000}$ in., requires an electromotive force of several hundred volts, and then, when a spark takes place, this is a disruptive discharge through the medium, not a conduction by it. The air does not conduct, so the discharge pierces a hole through it, just as it might through

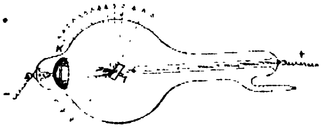
a layer of oil or a thin sheet of glass. But it was found by Schuster that even a low electromotive force, such as 1 or 2 volts, will send a current through air, if at some other part of the containing vessel, or even in another vessel opening into the first, spark-discharges are being made. The explanation of this is that when a series of spark-discharges are made through air or other gas, some of the molecules of the gas become *ionised*, so that a number of free ions are present moving about amongst the neutral molecules; and as these free ions carry charges they can serve as carriers of electricity from the anode to the kathode, by a sort of electrolysis. Gases can be ionised in several ways—by the effect of disruptive discharges, as we have seen; by contact with red-hot metal surfaces; by being shone upon with ultra-violet light; by molecular impact between the gas molecules; and, as we shall see, by the influence of Röntgen rays and of radium.

Electrons and Molecules. One conception of electrons is that they are minute electric corpuscles which dance attendance on atoms, as though they were satellites attendant upon some planet. If an electron (negative) is separated from an atom of a gas, that atom becomes a positive ion, and it is probable that in ordinary gases, when ionised, the electron joins itself to a neutral atom, thus transforming it into a negative ion. In an ionised gas any electrified body loses its charge, for it attracts to itself the oppositely electrified ions, and they neutralise its charge. A neutral molecule will consist of a positive ion and a negative ion in conjunction.

Electrons in Movement. The conclusion is forced upon us by the observed facts that electrons in movement, whether flying free or carrying atoms of matter with them, as in electrolysis, are an electric current. Whenever they are moving along in any direction they set up a magnetic field around them, and the presence of this surrounding magnetic field, which is the essential thing in the phenomenon of the self-induction of a current, acts as an inertia. This has led Lodge and others to speculate whether the ordinary inertia of matter is not really due to the self-inductive effect of the electrons which accompany the atoms. The electrons in the kathode rays travel with a speed a hundred thousand times greater than the speed of a rifle-bullet. Their inertia is proved by the mechanical impact they exert upon the vanes of a mill as mentioned above.

So long as the movement of the electrons is uniform and in a straight line, their inertia and their surrounding magnetic effect is constant; but if their speed changes, as when they are suddenly stopped or suddenly started, a new effect appears. During the period of change of speed the electron sets up waves in the surrounding ether, which travel off from the source with the speed of light. The more sudden the starting or stopping, the more violent will be the etheric pulse. If the electron vibrates, or oscillates, or revolves rapidly around an orbit, it will send off regular trains of minute waves, and these constitute the ordinary waves of light. Radiation, in fact, is caused by the vibration or revolution of electrons, or of the atoms with which the electrons are associated.

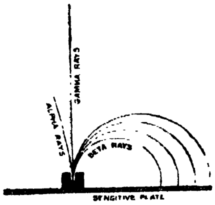
Röntgen Rays. Whenever kathode rays in a very highly exhausted tube strike on any surface they give rise to new and more penetrating rays, known from their discoverer as Röntgen rays, or X-rays. A special form of Röntgen-ray tube is depicted in **256**. Here a cup-shaped kathode, K, concentrates the radiant matter that is shot off from it upon a little platinum plate, T, which serves as a target or *antikathode*. From this target are emitted the Röntgen rays, which are observed by the light they excite upon a fluorescent screen, or by their action on a photographic plate. It is these rays by which the bones of the hand or in the living body can be seen and photographed. They are, like the waves of light, movements in the ether; but sudden, irregular pulses, not periodic waves. They travel with the same speed as light. They render electrically conductive the air through which they pass, by ionising it. If they fall on a charged electroscope it is discharged; and the rate at which the instrument loses its charge can be used to measure the intensity of the rays.



256

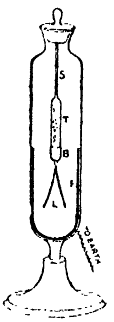
Radium and its Rays. The discovery of the Röntgen rays stirred up other investigations, and led to the discovery of the emission by the metal uranium and its compounds of some highly penetrative rays, known as *Becquerel rays*, from the discovery having been first published by Becquerel, though independently discovered by the writer. It was then found by Madame Curie that one of the ores of uranium, called pitchblende, was more powerful than uranium itself. This led M. and Mme. Curie to discover in uranium residues the wonderful and excessively rare metal *radium*. By patient and laborious chemical analysis they succeeded in separating a nearly pure salt of radium. But each ton of the mineral furnishes only a few grains of radium, and each grain of radium costs about £60, which is at the rate of £26,000 per ounce. The rays emitted by uranium and by radium have the property of causing a charged electroscope to discharge itself. If a piece of either of these substances is placed near an electroscope, like **250** [page 4022], the gold leaves fall together, the time taken for the discharge depending on the activity of the specimen. Samples of radium have been produced which are a million times more powerful than an equal piece of uranium. Radium has been found to emit three different kinds of rays, known as the alpha, beta, and gamma rays. The *alpha* rays are believed to be identical with the diakathode or canal rays, and consist of atoms positively charged. The *beta* rays are practically the same as the kathode rays, and consist of flights of negative electrons. The

gamma rays are practically identical with Röntgen rays. They are extremely penetrating and will pass through a steel plate an inch thick. If a small piece of radium is put into a hole drilled in a block of lead, placed upon a sensitive photographic plate, and subjected to a magnetic field, the *beta* rays are deflected in circular paths by the magnetic influence, and act on the photographic plate at one side, while the *alpha* rays are slightly deflected in the opposite direction. The *gamma* rays are not deflected by the action of the magnet. This is illustrated in 257, where the direction of the magnetic field is perpendicular to the plane of the paper. The *alpha* rays have very little penetrative power, and are stopped by even a thin sheet of paper. If a fluorescent screen made of sulphide of zinc is held close to a minute speck of radium, it is noticed that a luminous spot appears, due to the action of the *alpha* particles. Examining this spot in a microscope, Crookes observed it to present the appearance of a shower of sparks.



257

Strutt has devised a most ingenious perpetual clock [258], consisting of a gold leaf electroscope, L, suspended on an insulating support, S, with a milligram of radium enclosed in the tube, T, ending in a brass box, B. The *beta* rays emitted from the radium carry away negative electricity, leaving the electroscope positively charged. So its gold leaves gradually diverge until one of them touches against a plate of foil, F, connected to the earth. This contact discharges the electroscope, and the leaves drop down; but they slowly open again until they again discharge; and so on, indefinitely, at perfectly regular intervals of time. This "clock" will go on until the radium loses its activity—a process probably requiring thousands of years.



258

Energy of Radium. Beside these rays, radium and its compounds—for example, the solution of chloride of radium—slowly give off a heavy vapour, called the *emanation*, which forms deposits on the surrounding surfaces and makes them also radio-active. More surprising still, radium is found to be always slightly warmer than its surroundings, and is therefore continually giving out energy. To account for this apparently perpetual supply of energy, Rutherford has suggested that the atoms of radium are themselves slowly disintegrating, this disintegration being accompanied by an evolution of their intrinsic energy. In fact, the emanation slowly changes and evolves the gas helium. Radium appears to undergo a series of transformations, some rapid, some slow. The atom of radium, when it parts with an alpha particle, becomes an atom of the emanation; the atom of emanation, when it disintegrates, parts with another alpha particle, and becomes a solid called "radium A." "Radium A" rapidly gives off another alpha particle, and becomes "radium B." "Radium B" is transformed into "radium C," without any emission; but "radium C" gives off not only alpha particles, but also beta and gamma rays, and changes to "radium D." This is a very stable product, but it is slowly transformed without emission into "radium E," which gives off beta and gamma rays only, and quickly changes into "radium F." The final result of all these transformations is yet uncertain, but apparently the original radium itself changes so slowly that in 1,300 years it would be only half transformed. The rapidity of these changes is examined principally by aid of the electroscope [250, page 4022]. It is charged, and the radio-active substance to be examined is brought near it, the rate of the discharge so produced being noted.

Besides uranium and radium, another heavy metal, thorium, possesses radio-active properties and emits rays.

According to Ramsay, when an atom of a metal loses an electron it is transformed into some other element, but may go through a series of transformations. No atom can lose or gain an electron without experiencing a change in its properties.

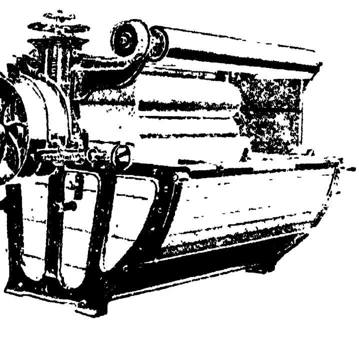
Matter and Electricity. It is then seen that electricity, though usually associated with the molecules and atoms of matter, can—at least, in the negative state—be recognised as existing in minute quantities or corpuscles having apparently a mass 1,000 times smaller than the atoms of matter. Moreover, it has been shown that when incandescent bodies are emitting light, that which sets up the light waves in the ether is the movements of the negative electrons in vibration. What the precise relation of the electron to the ether itself may be is a matter for speculation. A further speculation is that all mass—that is, all matter—may consist of systems of electrons. Professor J. J. Thomson has suggested that the atoms of the ordinary elements as known to the chemist may consist of systems of negative corpuscles grouped about a central mass of positive electricity, some such groupings being stable, others unstable. Any unstable groups might readily emit some of their corpuscles and change to other more stable forms of lower atomic weight. This might account for the singular transformations of radium and the electric phenomena accompanying the emanations and rays which it emits. We may be yet very far from having arrived at any final knowledge of these relations; but this is at least clear, that a great deal more is now known about the nature of electricity itself than was known ten years ago.

Continued

Group 28 **TEXTILES** **29** Continued from page 3996	# WOOL FINISHING **Scouring, Burling, Darning, Felting, Teasling, Cropping, Brushing and Steaming. The Machines and their Operations**

By W. S. MURPHY

SOME classes of cloth are finished in the factory; others are handed over to outside specialists, such as bleachers, dyers, and calenderers. We cannot lay down any invariable rule, however, because practice varies indefinitely. It can only be said with certainty that the separate finishing operations may be studied to best advantage under specialised conditions. We purpose, therefore, considering the textile finishing operations in two divisions: first, as a factory process, directly succeeding the weaving; secondly, as a special process, carried on in establishments wholly separate from the spinning and weaving factories.



188. SCOURING MACHINE

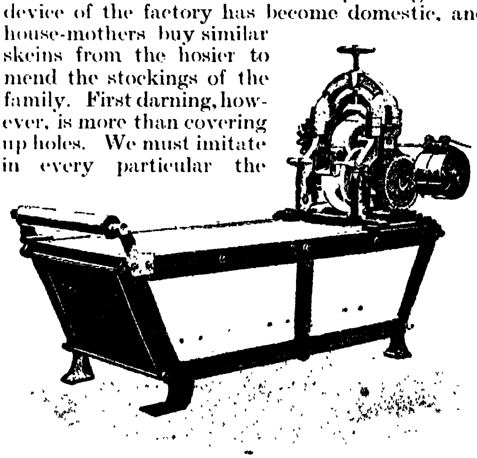
Even this division may involve us in repetition; but theoretic consistency is not esteemed a virtue in practical industry.

Course of Operations. Our aim in this finishing process is to produce a cloth of solid body, unshrinkable under water and changes of temperature, with a fine nap lying evenly on the surface, which does not spot or allow dust to penetrate the fibres. We want, in short, a cloth which wears well, and keeps its fresh appearance after a considerable amount of use. The means adopted to accomplish these objects vary a good deal; but the following operations are generally employed: *Braying* or *scouring*, *burling*, *first darning*, *fulling*, *milling*, *second darning*, *scouring*, *stentering*, *teasling*, *cropping*, *brushing*, *steaming*, *darning*, *damping*, and *pressing*. Some manufacturers repeat these operations, or some of them, several times; others go straight through, relying on the efficacy of the one operation.

Braying or Scouring. When the cloth is taken off the loom it is full of size and oil. Having served the purposes for which they were employed, these substances must be got rid of by the operation we name *braying* or *scouring*. Any machine which will hold the detergent liquid, and carry the cloth through it, serves our purpose. A solution of 2 lb. of soda to 1 lb. of soap forms a good scouring liquid. After being run through the scouring machine [188] for 20 minutes or so, the cloth should be rinsed in water and cleared of soap. On the end of the rinsing machine a pair of squeezing rollers take away the superfluous water, and then the cloths are laid in the centrifugal drying machines, or *whizzers*, as they are called. These and the other finishing machines illustrated are made by Messrs. Wm. Whiteley & Sons, Ltd., Lockwood.

Burling. Scouring should have cleared away the size and grease and left the cloth bare. Our object is to detect and remedy any defects which may be in the cloth, such as knots, scobs, flying threads, flecks, and breaks in weft or warp. Over the roller hung in a good light the cloth is run, while we watch its surface for faults. The light penetrates the cloth and shows up every flaw; here appears the glittering point of a burr, there the soft cloud of a scob, and there the flying end of a loose thread. As each flaw comes into sight it must be picked out, or marked for the first darners. The work of burling requires quick eyes, a good knowledge of cloth, and deft hands.

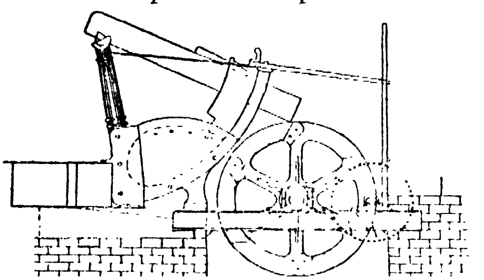
First Darning. Sometimes very serious defects occur in the cloth. Warp and weft may have broken at one point, or the tied knot of the mended thread may have slipped, leaving a hole. As each fault of that kind is detected in the burling, it is marked, and the cloth is handed on to the darner. On the darning table we find several rows of skeins of woollen or worsted thread wound on cards. Curiously enough, this device of the factory has become domestic, and house-mothers buy similar skeins from the hosier to mend the stockings of the family. First darning, however, is more than covering up holes. We must imitate in every particular the



189. FULLING TROUGH

weaving of the warp and weft so as to make the darn imperceptible.

Felting Cloth. Few operations in the woollen trade have been the occasion of so much speculation and controversy as this one of felting. Everyone agrees that woollen cloth has a felting property, greater in some wools than in others; but there are wide differences of opinion as to what constitutes the felting property. Yet the facts are plain and simple. The woollen thread, as we have noted often, is loose and open; wetted wool becomes flaccid and tends to cling. Wool fibres have serrated edges. Suppose the wool fibres have been soaked, and they are clinging together for mutual support, by bringing pressure to bear on them we can confirm the cohesion. But the fibres may tend to return to their former relations when dry. Some other factor must be brought in, and that factor is the serrated character of the wool. The scales of the outer skin of the fibres lie over each other like little plates of armour. When the wool is dry, the scales stand out, and under water tend to lie flat. Moreover, the scales are elastic, and spread out under a sharp blow or sudden pressure. Our factors are all gathered, and we shall try how they work out the theory. Fill up the cloth with a greasy substance easily discharged and of watery consistency; put the fabric under pressure at once elastic and firm. The fibres cling; the pressure brings the loose thread close; the serrations grip into and hold on to each other with a thousand little teeth—the cloth is felted.

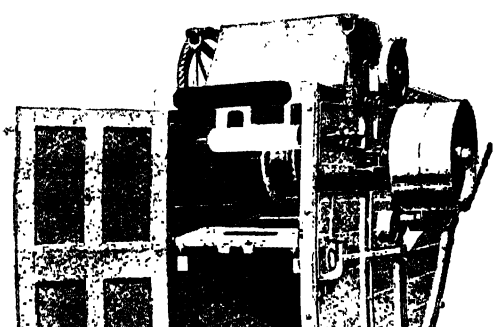


190. MILLING STOCKS

Fulling. Soft soap is the greasy substance used for fulling out the cloth for the felting machine. The soap greases the fibres, making them slip easily over one another, acts as a kind of protecting pad to the threads under pressure, or the blows of the milling stocks, and is easily discharged. The web of cloth is joined in an endless band, and stretched on the rollers over the fulling trough [189], where it is filled with the soft soap. Being so easily discharged, the soap requires to be renewed several times during the felting process.

Milling Stocks. The oldest form of felting machine still in use is the milling stocks. A pair of wooden slabs, with large heads, are geared on a frame above a sloping, narrow trough [190]. The heads of the stocks rest on the bottom of the trough, and the function of the gearing is to pull down and let go the end of each stock alternately. By this action the heads of the stocks fall by their own weight on the sloping bottom. When the cloth has been filled with soap it is laid on the fore-end of the trough, and as the stocks beat alternately upon it, it is slowly drawn to the other end. Here we have all the requisites of felting—the soap, the water, and the elastic beating of the fibres into close union.

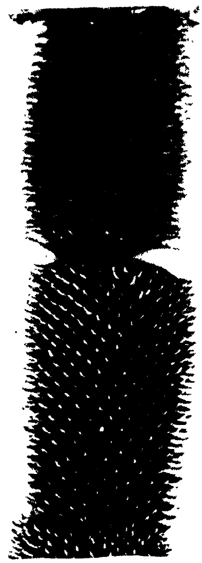
Milling Machines. The stocks have failed to satisfy the needs of woollen manufacturers in a variety of ways. Probably the most serious objection to them is that they are slow in action. New forms of milling machines have been placed at our disposal, very similar in structure though differing in minor details. Examining one we obtain an idea of the whole class. On the fore end of the machine [191] is a slotted guide board, with stop motion; above it is the guide roller, beyond which extends the contracting tube; the felting rollers are geared behind, forming the end of the machine. Two kinds of felting rollers may be used in the same machine if desired. Most commonly the under roller is flanged at the sides, while the upper roller is plain. But, to harden the grip on the cloth, one roller is sometimes made convex and the other concave. When working, the soaped web is laid on the guide board and led up over the guide roller, through the contracting tube, and between the felting rollers, which draw and felt the cloth, drawing the fibres closer and closer. On this machine the soaping must be frequently renewed and carefully watched so as to prevent friction.



191. MILLING MACHINE

Shrinkage. The degree of felting depends a good deal on the character of the cloth. The amount of shrinkage generally aimed at is from 5 in. to 7 in. on the width of narrow cloth, and from 10 in. to 12 in. on broad cloths. Fine twills and fancy woollens are seldom more than half milled. When a heavy cloth comes out of the felting machine neither warp nor weft should show a single open thread.

Milling Felt Cloths and Carpets. Felt cloths and felted carpets of all kinds require to be severely milled. Milling is an indispensable part of the manufacturing process of felt, not a mere finishing operation. When the felts come from the sulphurising-room, they are rough, harsh, and dry. On the fulling rollers the pieces are literally filled with soap, to endow them with the needed elasticity and to soften the fibres. As a rule, felts are milled on the stocks, because the heavy mallets work slowly over every fibre of the fabric. It is absolutely imperative that the milling of fine felts should be repeated over and over again till not a loose hair is visible. Fine felt should be indistinguishable, in outward appearance, from the finest superfine cloth. We have additional means of putting on a good finish, which shall be noted in time, but nothing can compensate for weak milling on the stocks.

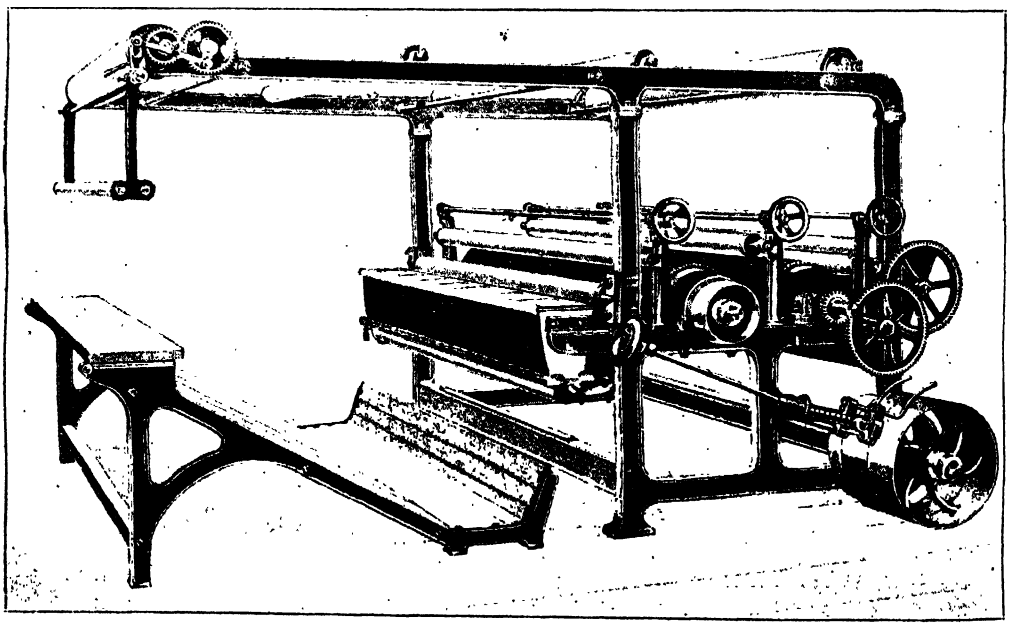


192. TEASLE

Scouring and Stentering. At this point the departures in practice are so numerous as to call for notice. We may combine scouring with milling, and many combined milling and scouring machines are in use. Again, some cloths are sent direct from the scouring to a drying and stentering, or *tentering*, machine, while others require more elaborate and careful treatment. One very common practice is to scour, half-dry, and then *cuttle*, or *age*. To cuttle, is to fold the cloth up in a damp condition, and let it lie for a few days. In any case we come to the stentering.

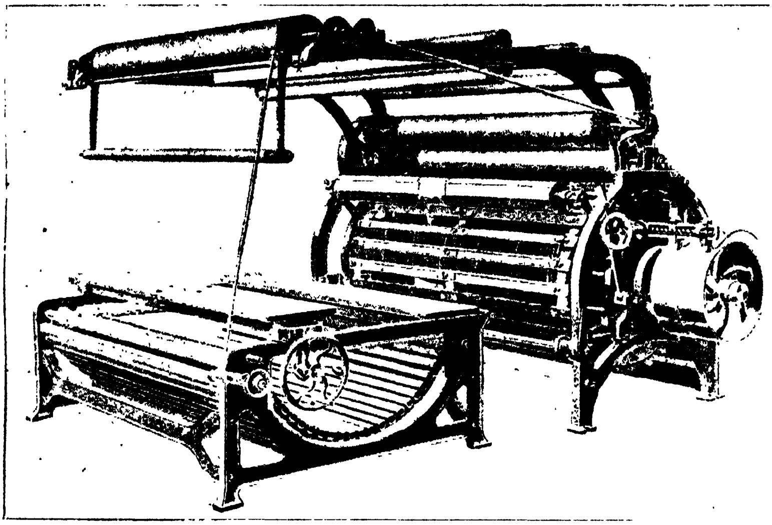
This machine is used in many departments of the textile industry, and is worth detailed attention. The main object of all stentering machines, of whatever model, is to stretch the fabric to its utmost breadth and width, and to confirm its form. The main structure of the stentering machine is two parallel lines of framing, fitted with hooks or clips to grip the sides of the cloth. When the cloth is introduced, the ends of the framing are so near to each other as to allow the cloth to be easily clipped in. But the mechanism is designed to draw the frames apart whenever the machine is started. While the cloth is being drawn in on the long frame, it is being stretched to its utmost width and length, and the relation of every thread kept true to every other.

Teasling, or Nap-raising. The cloth yet lacks that smoothness of texture which is characteristic of a well-finished cloth. Viewed through a magnifying glass, it presents the appearance of a rain-swathed and unshorn meadow. It must be shorn level; but if that were attempted without due preparation the result would be very unsatisfactory. To make sure that all the inequalities shall be removed, it is necessary to raise them all up. This operation



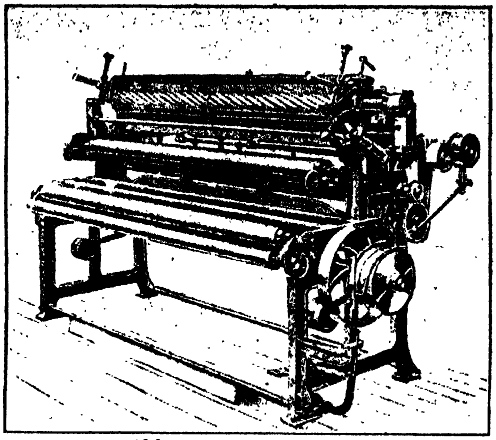
193. BRUSHING AND STEAMING MACHINE

is accomplished by the aid of a cone-shaped burr, spiked like the head of a thistle [192]. The plant on which the burrs, or teasles, are grown, named *Dipsacus Fullorum*, is cultivated in France and England solely for the woollen industry. Yorkshire teasles are highly esteemed. Looking into the cones, we see that the spines are sharply hooked, and pointing downwards from the top. Smooth and elastic, the spines are evenly set, forming an exquisitely proportioned teaser which we have vainly sought to supersede by mechanical arts. The teasles are fastened in horizontal rows, two deep, on the frames of the gig cylinder. The raising gig is a simple machine [195]. The teasle frames are mounted on a wide cylinder composed of staves fixed on the spokes of a driving shaft. Close to the cylinder hangs the cloth beam, and extending over like a canopy is the frame which, in conjunction with a driven scray in front, holds the web taut, and sends it round upon the gig cylinder. The cloth frame and beam run in the direction opposite from the motion of the gig cylinder, thus working the surface of the cloth against the teasles.



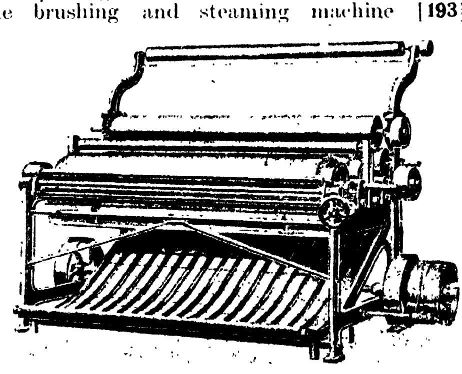
195. RAISING GIG

Cropping. Looking along the surface of the raised cloth, we see the fibres standing up irregularly, some long and floating, others stiff and short, and all mingled with fluff. To free the fibres and make them stand clear we employ what are called setting-up brushes. This may be done either on a separate machine [196], or by brushes on the cropping machine [194]. For the latter, which is the most up-to-date method, good machines, resembling in framework the teasling gig, have been devised. The setting-up brushes occupy the position of the teasling cylinder, and beyond these is the spiral cutting roller. Knife-blades form spirals round this roller, which revolves on a cutting bed. Some of the simpler machines have ledger blades for setting the nap against the cutter; but the best and newest machines are different. Makers of cropping machines undertake to supply any form of rest or bed, from the fixed solid to the elastic rubber rest [197]. Hard, heavy cloths can best be cut on the solid bed or ledger blades; but the greater variety of cloths require an adjustment more delicate. To obtain a smooth surface, the cloth may be passed twice, thrice, or oftener, through the machine.



194. CROPPING MACHINE

Brushing and Steaming. This is the beginning of another stage in the finishing process. The fabric is smooth, but two special qualities are yet wanted. The surface should be lustrous and resist the spotting of rain. In general structure the brushing and steaming machine [193]

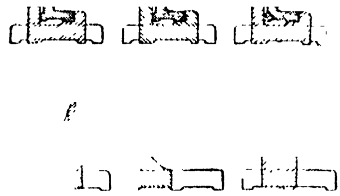


196. BRUSHING MACHINE

closely resembles the teasling gig. The steam-box is placed in front of the main body of the machine, and the brushing rollers revolve behind it. A scray before, and a canopied frame, with rollers, above, carry the cloth round, bringing it over the steaming-box and through the brushing rollers. When it emerges from this machine the cloth has a superficial finish, hich is to be deepened and confirmed.

Repeated Operations. After brushing and steaming, the cloth is handed on to the burlers, who make a second inspection and take away the small knots and loose threads recent operations have brought to light. Next, the fine darners repair any little holes which may have shown themselves. Then the cloth is pressed in one or other of the many kinds of pressing appliances at the disposal of the trade. In former days, the cloths were folded over thin and glossy sheets of pasteboard, a board between each fold, and laid in the press, which was screwed down by strength of arm; but that fashion has almost gone, and now the pressing is done on a variety of machines, ranging from the simple hydraulic to the complex rotary pressing machine. A second steaming follows. The object of this is to impart lustre to the fabric, and one very good method is to wind the cloth round a perforated roller, or tube, one end of the tube being sealed, while the other is threaded for a screw joint. A steam-pipe is screwed on to the roller, and the steam blown through the cloth. Given another brush the cloth is again pressed, care being taken that the folds of the first pressing are not repeated. When brought out of the press, in which it should be kept for a day, the cloth needs but a little brushing to make it fit for the outside market.

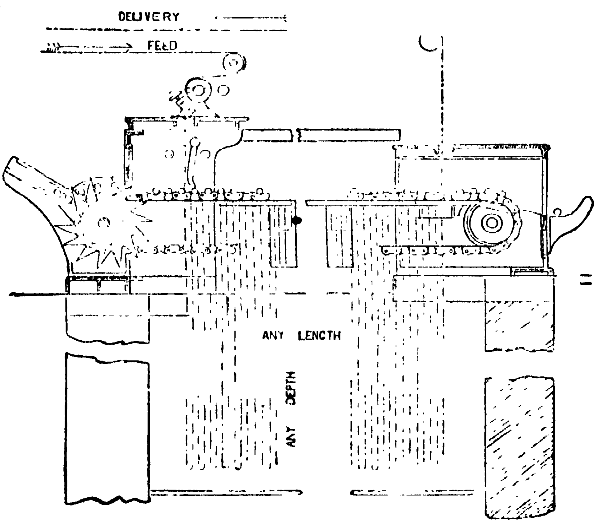
Cloth Character. It cannot be too strongly emphasised that the finishing process is not, and never can be, a rigid system. Before the cloths arrive at the finishing department they have taken on a distinctive character, which requires to be considered. Every class of cloth has to be finished according to its own nature.



197. CROPPING MACHINE CUT BEDS

Worsteds. Except in one particular worsteds are finished by the same process as woollens. But this has to be specially noted. Worsteds are not felted; the beauty of many worsted cloths largely consists in the patterns which the threads form on the surface; if felting were resorted to all the weaver's trouble would be thrown away. But, as we have seen, all kinds of cloths composed of wool fibres have a tendency to shrink in water and under changes of temperature. Though woven of threads finely spun, a cloth, unless otherwise prepared, would be certain to shrink in water, and the shrinkage would be very readily confirmed by the merest pressure.

Shrinking. The only way to prevent irregular shrinking of worsted cloths is to shrink them thoroughly in the factory. After being scoured and dried, the cloth is damped and hung up on the shrinking machine. Shrinking machines are various, but we shall examine a very efficient and typical one [198]. In the shrinking-room, an endless chain extends between two wheels, fixed at opposite sides of the apartment; the chain supports rods which hold the cloth suspended. The fore eel has star points which bring the rods in by one, and let them on to the chain. From feed rollers above the machine the cloth es down on the far side of the rod, being ught in by the star wheel, and when the e required depth, a projection from the frame automatically holds the cloth against the rod, while the chain goes forward the breadth of a link. Being held, and so prevented from falling further, the cloth naturally makes a fold and turns upward, falling over the next rod on the chain, which gives it another point of descent. In this way the long length of the web is suspended in fold after fold. When the cloth has shrunk and dried the apparatus is reversed, and the cloth is re-delivered to the beam.



198. SHRINKING MACHINE

With the difference we have seen, worsted cloths are finished in the same way as woollens. Scoured, burled, darned, brushed, steamed, pressed, steamed, and again pressed, the woven fabrics are carefully finished.

Continued

BOX AND BALK JOINTS

Joints Used in Box-like Constructions. Butt, Rebated, Mitred, and Dovetailed Joints. Fished and Scarfed Joints

continued from page 4014

By WILLIAM J. HORNER

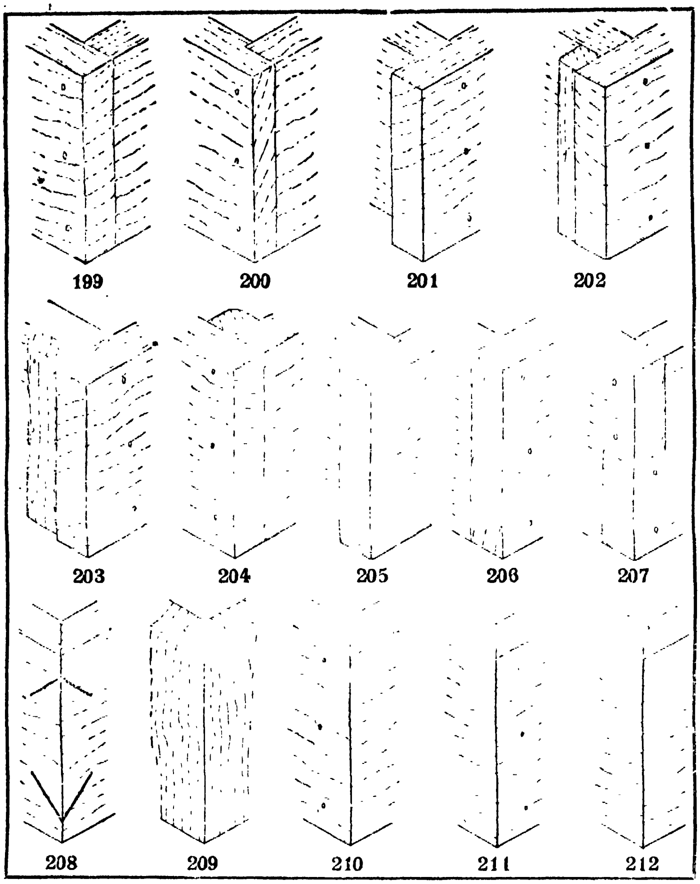
Joints Not in the Same Plane. We now come to a class of joints employed more in small work than in large, and consequently more used in joinery and cabinet-making than in carpentry. The weaker and more refined forms, such as the secret dovetail and mitre joints, are scarcely used at all in carpentry, but the rougher and stronger ones are necessarily employed a good deal in all woodworking trades, and as we are dealing with joints in general it would be difficult to select some and omit others that are in use, though only occasionally adopted in carpenters' work. The class of joints about to be described are those employed in uniting wide and comparatively thin pieces of wood at right or other angles—as, for instance, in boxes and cases of all kinds, drawers, etc.

As in the earlier joints described, we have first the simple butt joint [199] held together by nails or screws. Glue is of no use for holding such a joint, though on rare occasions it might be employed as a slight reinforcement to nails and screws. In such a case the pores of the end grain must be stopped by a preliminary coat of glue, which is allowed to dry before applying fresh glue to unite the parts. This, however, does not make a strong glue joint, for that is impossible where end grain is concerned. The ordinary butt joint, nailed or screwed, is commonly employed for all kinds of rough work where ends meet at right or other angles. Ordinary boxes, packing cases, etc., are usually nailed together with butt joints, as shown in **199**, the piece which laps over the end grain being usually the longer way of the box or other structure, and the piece between the shorter. If the box measures the same each way, of course this rule cannot apply; but sides and ends are always kept uniform—that is, ends always fit between and sides lap over.

Improved Butt Joints. An improvement on the plain butt joint is to rebate the end [**200**], thus forming a shoulder, which prevents the end piece from being knocked or forced inwards; and as the side abuts against the end, both pieces are able to resist external pressure without injury to the joint. If the rebate be cut as in **201**, an inch or so of wood extending beyond the end piece, the latter will be able to resist also a great deal more internal pressure than if simply depending on nails or screws, as in the two previous examples. Another advantage of the extended end is that the nails are less likely to split the wood or break out of it. In many cases, however, there are serious objections to having such an extension. Another joint with extended ends but without a rebate is shown in **202**. In this case a batten is nailed across the extension for the end piece to bear against. This practically forms a rebate on the outside which enables the end to withstand outward pressure—just the reverse of **200**, in fact. This is useful in work that is frequently taken apart, because the batten strengthens and keeps the side from warping or splitting. Fig. **203** shows a batten on the end piece instead of on the side This is a method commonly adopted in making packing cases, the end being thus strengthened and the lap of the joint increased. It is simply a repetition of the butt joint, but with the end thickened and fortified. Another variation of this is shown in **204**, in which the joint is strengthened by a batten or block inside. Fig. **205** is a method of making a corner joint with extended end so that it will stand either tension or compression in any direction. It is done by making a veed or dovetailed rebate, into which the end must be slipped sideways. This involves more work in making than any of the preceding joints, and for some purposes the extended ends would be objectionable. It may be simplified by dovetailing only one side of the rebate. Fig. **206** shows another form of rebated joint, in which the rebate is made very narrow, extending from the inner face of the end piece to only about one quarter or a third of the thickness of the end, the latter being cut to fit it. This allows end grain beyond the rebate without any extension beyond the outer face of the end piece, thus forming a very neat and satisfactory joint not greatly inferior in strength to a full-width rebate like **201**. Another form of joint not very often employed and suitable only for rough work is that shown in **207**. It is a simple half-lap joint, almost unrecognisable as such because of the great depth of the members compared with their thickness.

Mitre Joints. Next in simplicity to square butt joints come *mitre joints*. As far as neatness goes, a plain mitre joint, like that shown in **208**, is an ideal method of uniting two pieces of wood meeting at an angle. In joining mouldings there is practically no choice but a mitre joint, or the more troublesome method of cutting the end of one piece to fit the contour of the other. This latter method is sometimes adopted, and is called a scribed joint.

Weakness of Mitre Joints. Unfortunately, however, the mitre is too weak to be employed for anything where strength is essential. Like the butt joint it always depends entirely on something else as a means of holding it together, while at the same time it is a much more difficult joint to hold than a square butt. Nails or screws can be used,



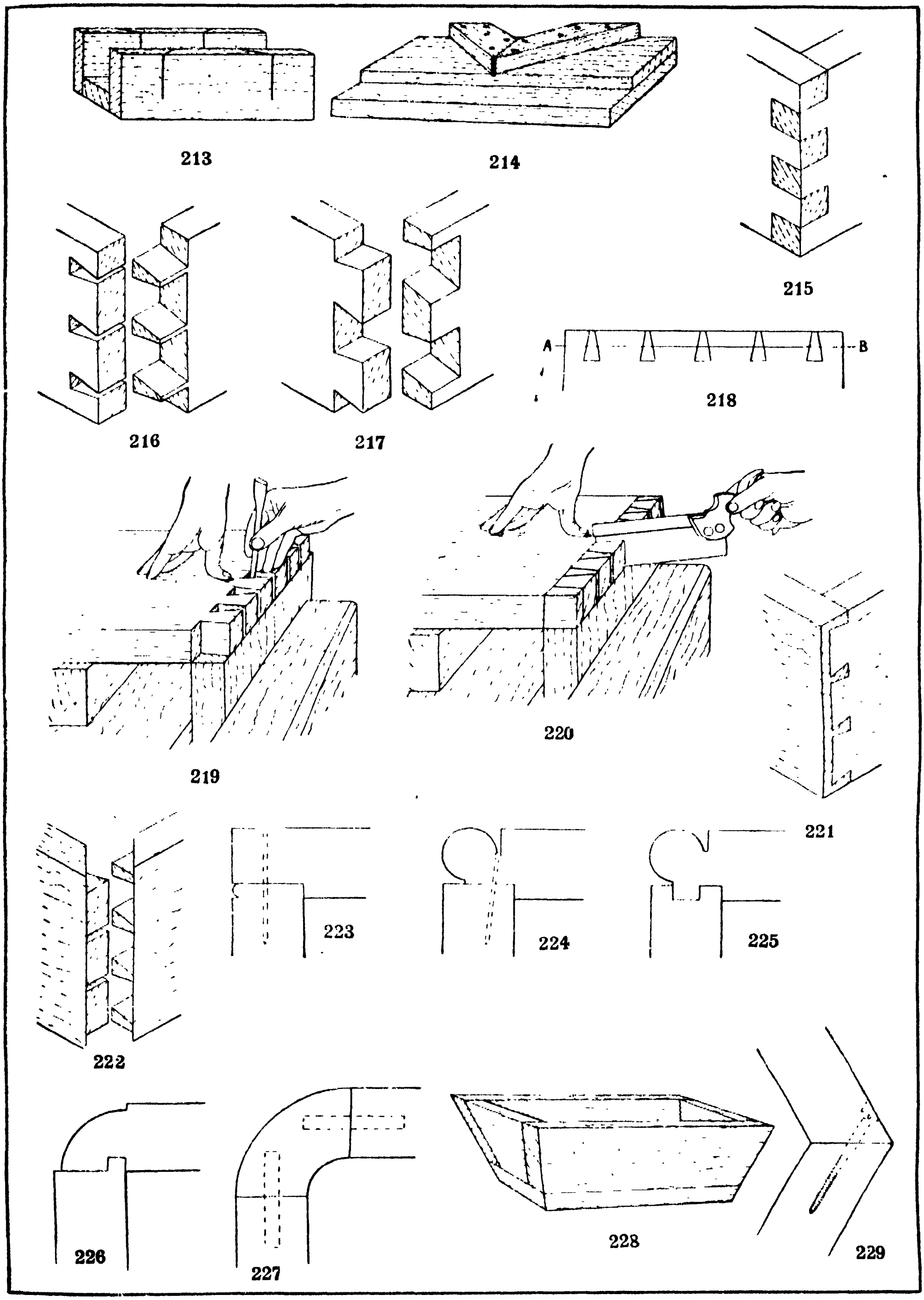
VARIOUS FORMS OF BUTT, REBATED, AND MITRED JOINTS UNITING PIECES AT RIGHT ANGLES

In cabinet-maker's shops veneer is handy for this purpose. The grain of the inserted pieces must run transversely to the joint, otherwise they would be of little value. After the glue is set they are trimmed off flush with the outside surface. Another more troublesome method less frequently employed is to cut slots across the joint for the reception of dovetail-shaped keys which are glued in similarly to the thin slips and trimmed off after. These methods are rather unsightly and are adopted only because something is necessary to hold the joint together. In the comparatively few cases where the mitre joint runs with the grain of the wood [209], glue may be sufficient to hold it, or it may be strengthened by wood blocking in the interior angle, as shown in the square butt [204], provided, of course, that there is no objection to the blocking. In an end grain mitre, like that shown in 203, the joint might be strengthened by nailing or screwing a block in the angle; but it would not be advisable to glue it, because, as the grain would cross, unequal shrinkage would be almost certain to break the hold of the glue. Frequently a tongue is inserted, as in **209**, but in end grain especially this is troublesome to do without a circular saw and fixtures for holding and guiding the wood. Fig. **210** is a mitre joint which differs from the foregoing two in having a square shoulder or stop formed at the interior angle of one of the pieces, the chief reason for it being that the piece with the stop is thicker than the other, and it is desired to keep the mitre angle at 45 degrees. It also makes a joint slightly stronger and more convenient for nailing than a plain mitre. Fig. **211** is a more complicated form, eminently suitable for nailing, and very strong. In this case the joint is mitred only for a short distance back from its outer angle, the remainder being a rebate. Fig. **212** is a still more complicated form, often held together by glue only.

All these joints are marked out with square and bevel, scribed lines being made, or if the dimensions of the work that is to be mitred together are unimportant, plain mitres may be sawn against a mitre block [**97**, page 3755] or in a mitre box [**213**] or cut with a mitre machine; and usually are planed after to an accurate fit on a mitre shoot [**214**], of which

but, owing to the inclination of the surfaces, they are troublesome to insert, and the joint is not strong when they are in. Moreover, as mitre joints are used chiefly when appearance is the first consideration, nail or screw holes are objectionable. Glue holds slightly better on grain cut at this angle than on direct end grain, and it is generally used in a mitre joint, but always in conjunction with other fastenings. Fine nails are often used to hold mitre joints, and are driven in the same way as they would be into a square joint, the nail being entered at right angles with the face of the first piece and running into the other parallel with its grain. The mitred parts are held in position in a mitre cramp, or one is held in an ordinary vice and the other carefully kept in position by the hand while nailing. When screws are used they are generally inserted to go through the joint at right angles to its surface.

A very common method of uniting a mitre joint is shown in **208**. It consists in running sawcuts at an angle across the joint while the parts are clamped together, or after the joint has been glued, and gluing slips of wood of the same thickness as the sawcut into them.



JOINTS IN WOOD

213. Mitre box **214.** Mitre shoot **215.** Lock corners **216.** Ordinary dovetails **217.** Cistern dovetails **218.** Method of marking out **219** and **220.** Marking pins from dovetails **221.** Lap dovetails **222.** Secret dovetails **223-227.** Ornamental corner joints **228** and **229.** Joints not at right angles

there are several forms, **214** not being suitable for long joints like **208** and **209**. The more complicated forms have to be carefully marked out, and sawn and worked to the lines with chisels and rebate planes.

Lock Corner Joints. We now come to an important variety of joints differing from all the foregoing in being fitted to each other by a series of projections and corresponding recesses, instead of a continuous projection, as in the case of a tongue and groove and others of similar character, or joints in which there are only one or two projections, as in tenons and laps. The simplest form of this class is the lock corner [**215**]. This is an excellent joint which, held by glue alone, is strong enough for almost any purpose. It is, however, not often made by hand because there is as much work in it as in dovetailing, and hand workers prefer the latter if a first-class joint is to be made. Lock corners, therefore, are almost invariably cut by machinery, but owing to the prejudice against their appearance they are employed only for a rough class of work.

Dovetail Joints. Very closely allied to the lock corner is the *dovetailed joint*, which is considered the best possible for uniting ends of wood at right angles. Fig. **216** shows the ordinary form and proportions of dovetails, the two pieces being separated. Fig. **217** shows a form in which *pins*, and spaces or *sockets* are of equal width. This is sometimes called a *cistern* dovetail, because it is used for wood cisterns and large heavy boxes. It is rather stronger than **216**, but the appearance of the latter is considered better, and so it is almost universally employed for light and small work. The ideal shape is considered to be dovetails, with the narrowest possible spaces between —that is, a space no wider at its narrowest part than the thickness of the saw; and where appearance is of more importance than strength, this proportion is often adopted. But the usual proportion in ordinary work is that shown in **216**, in which the dovetails are about four times the width of the spaces between them, the measurement being taken on a line half-way between roots and points [A, B, **218**]. The angle of the dovetails is about 80 degrees with the ends of the wood. A more acute angle renders that portion of the wood liable to shear away in line with the grain. As in the putting together of ordinary butt ends, like **199**, so in dovetailed ends; if the box or frame be longer in one direction than in the other, the dovetails are cut on the longest sides, and the pins which fit between them on the shortest. A gauge is set to the thickness of the wood that is to be dovetailed. In most cases, of course, sides and ends are of similar thickness, and the gauge is set to that dimension and used on the ends of all the pieces alike, gauge lines being marked on both sides of each end where dovetails are to be cut, and also continued over the edges, so that a line goes completely round each end, indicating the length of the dovetails.

Marking Dovetail Joints. As one part is marked and cut first and the part which has to fit it is marked directly from it, it is not essential that the marking out of pins or sockets should be done other than roughly by the eye, but usually it is done accurately by measurement. Some men start by marking out the dovetails or socketed portions, while others are in the habit of marking the pins first. It is not a matter of any importance, but the first method is preferable when a quantity of parts are being done, and it is desired to cramp and saw a number together.

To begin by marking out the socketed part, the line A B [**218**] should be gauged or pencil-marked half-way between the roots of the dovetails and the end of the wood. This is the line on which the divisions are made, the inclined lines of the sockets cutting through the divisions on this line and extending to the roots and tops of the sockets where the divisions to mark from could not be so conveniently made. To proportion them roughly one-third of the thickness of the wood may be taken as a suitable width for the sockets and four times that amount for the intervening dovetails. These divisions are made on the line A B, and modified to suit the width of the wood. At the edges of the wood, half dovetails are formed, or, if desirable, more than half, in order to give a reasonable thickness of material on the outside. A bevel is set to the angle of 80 degrees, and used against the end of the wood to scribe the lines in the same way that a square would be used for marking right angles. When, as is usually the case, two sides have to be marked and cut they are clamped or screwed together and treated as one piece, thus saving time. The bevelled lines of the sockets are next cut with a dovetail saw, or if large, with a tenon saw, the wood being held end upwards in the vice, and the cuts being made down to the gauged line which marks the roots of the sockets.

Dovetails are usually put together a sawn fit, only the end grain at the roots being finished with a chisel. When sawn down there is a choice of two methods of procedure. One is to clear the sockets out first. This would be done with a bandsaw if one were available, but by hand they are either partially cut with a bow saw or else by mallet and chisel, working from each face of the wood in turn. In any case a chisel must be used for finishing exactly to the gauge line. For this purpose a chisel with sides bevelled to the angle of 80 degrees or more is more convenient than a square-sided one. Then, the end to be fitted to it is placed in the vice and scribed from it, as shown in **219**. The other method is to mark the end with a saw inserted in the saw cuts before the spaces are cleared out [**220**]. This method would be decidedly better if the saw mark represented exactly the cut, but to make the pins and sockets a close fit the saw must afterwards be kept a shade to one side to allow for the thickness of the cut. Either method may be adopted, marking with the saw generally being preferred. The parts are numbered or marked to show how they go, and then sawn down and cleared out with a chisel, and are ready to go together.

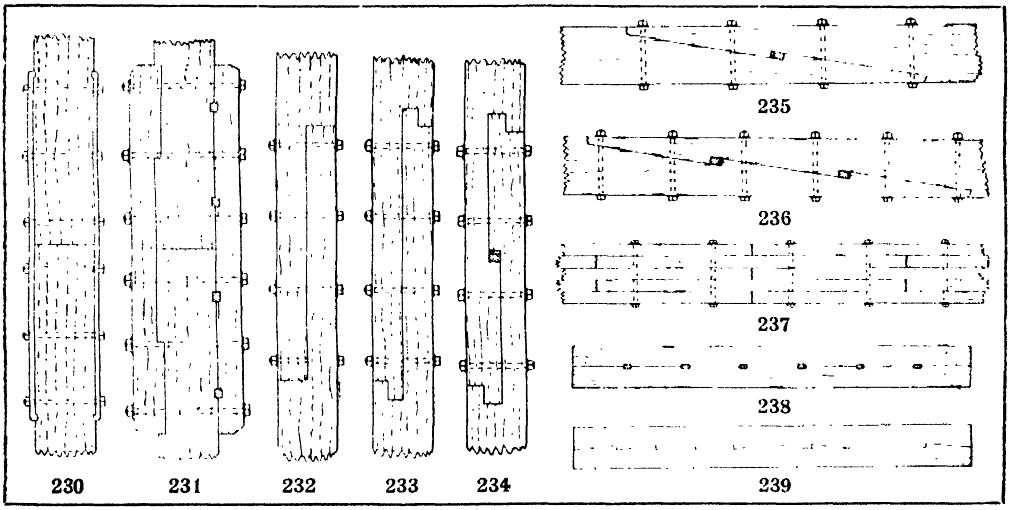
Lap Dovetails. Lap dovetails [221] are used chiefly for drawer fronts, the front being made to lap over and conceal the ends of the dovetails so that the latter are visible only in the sides when the drawer is open. The thickness of the lapping or covering portion on the front is usually the difference in thickness between front and sides, generally about ¼ in. or so. This does not materially affect the method of marking out and cutting them already described, except that the saw cannot be run through in cutting the front.

Secret Dovetails. Secret dovetails [222] are concealed within what appears from the exterior to be a plain mitre joint. They are employed only in high-class work for the sake of appearance, the joint being weaker than ordinary dovetailing, and more troublesome to make. The dovetails are simply gauged back short of the ends of the stuff, and otherwise marked and worked in the ordinary way, except that they have to be cut out, chiefly by the chisel alone, because the saw cannot go through. The wood extending beyond the ends and sides of the dovetails is then bevelled to form a mitre joint. Another method frequently adopted, but not so strictly a secret dovetail as the preceding, is to mitre only the front and leave the ends square, which gives the joint an exterior appearance like **211**. It is, in fact, a double lap, instead of a single lap like **221**, the corner being mitred to permit the laps to come together. In another form the lap is not mitred, but appears on the exterior as a plain lapped joint like **200**.

Dovetailed joints are usually held together by glue alone, though it adds to their strength if they are nailed as well. Before gluing, the parts should be tried together to see that they fit properly. Then plenty of glue should be applied to the end grain of the pin spaces, and a little to all parts that come in contact, using a small brush or thin slip of wood in the sockets. In finally driving together, the wood is not struck directly with a mallet, for fear of bruising or splitting it if the pins do not go down regularly, but a large block of wood is laid on the surface, and blows with a mallet or heavy hammer delivered on this, changing the locality of the blows as required. The fit, of course, must not be so tight as to necessitate very heavy hammering, or there will be a risk of splitting.

Ornamental Angle Joints. Figs. **223** to **227** illustrate methods of ornamenting and concealing joints in wood meeting at right angles, the forms of the actual joints not differing in principle from those previously shown in **199** to **212**.

Joints at Other than Right Angles. These are frequently necessary, and there are two main varieties. One, in which the pieces meet at right angles in one plane but not so in the other, **228** being an example; and the other, in which they meet either at an obtuse or acute angle, **229** being an example of an obtuse angle. In either of these cases most of the joints already described are applicable, making the necessary allowance for the different angle. This in most cases gives more trouble in making them, especially the dovetail. The pins and sockets in this case should be parallel with the sides of the wood and not marked from the ends unless two bevels set to different angles are used, for the angle of 80 degrees, sloping alternate ways from the end, would tilt the dovetails out of parallel with the sides. Such a joint would go together and is sometimes employed, but it is not the usual method. The extra difficulty, however, in all points of this kind is more in the marking out than anywhere else. The square generally has to be discarded and a bevel used in its place. Even in a simple butt joint [228], the fitting is considerably complicated by the slope of the sides and ends, which throw at an angle everything which in ordinary work would be cut square. This necessitates the use of the bevel, and careful marking out.



JOINTS IN BALKS

Fished and Scarfed Joints. These are joints used in lengthening balks and timbers of large section in heavy carpentry. In these, as in all others, the kind of joint adopted depends on the nature of the stress it has to sustain, or whether it is for temporary work or permanent service. There are two main varieties of joint used for uniting large timbers end to end, each well adapted for resisting corresponding stresses. These are joints to resist compression, and those to resist bending and shearing and some amount of tension. The former are required for posts and vertical timbers, the latter for horizontal beams.

Timbers which stand vertically and have to resist compression endwise should always have square joints, never scarfed, veed, or sloping surfaces. The simplest way to joint for this purpose is to butt the square ends together and bolt fish-plates to the sides, as shown in **230**. Fish-plates may be either of iron or wood. In the latter case, to make the joint equal in strength to a solid timber, the combined thickness of the plates should be equal to the thickness of the timbers joined. Iron plates are usually preferred, sometimes laid flat on the surface, and sometimes with their ends turned in [230].

Fish-plates are generally made in length equal to about six times the thickness of the timber, hard wood requiring less length than soft. Fig. **231** is a joint connected by wood plates. The plates might be bolted flat on the surfaces without the indentations shown, but the latter enable it to better resist bending and tension. Two methods of indenting are shown in this illustration. That on the left, where the plate is fitted into the beam, is known as tabling, and that on the right, where separate keys are used, as cogging or joggling or keying. These greatly relieve strain on the bolts. A half-lap joint like **232** is neater than either of the preceding, and in many cases would be sufficiently strong in itself without the addition of fish-plates.

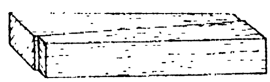
Improved Fish Joints. A still better form would be to cut the lapping ends in a series of steps, which leave each timber thick where its reduction starts, and thin at its extremity. Fig. **233** is a more complicated joint of the half-lap class, quite as strong in compression, but able also to resist more transverse stress than either of the preceding. It may therefore be considered superior in every way, but is more troublesome to make. A further improvement on this is shown in **234**, the joint in this case being tightened by driving a key through the slot cut in the centre. The advantage of this is that the joint can be more easily fitted together, and can be keyed to a tighter fit than would be possible if the parts had to be driven together sideways and left at that. When a beam has to be fortified against side strains as well as downward pressure, the joint is often indented longitudinally at each end of the lap instead of being cut straight across.

Scarfed Joints. All the examples so far have been suitable for vertical timbers, but we now come to scarfed joints for tension and bending rather than compression.

A scarf is a bevelled or sloping joint [**235** and **236**]. In its simplest form, which is not very strong, it is a plain, flat surface at an angle. In compression the surfaces of such a joint would tend to slide over each other and so break the joint; and even in more complicated form, with the surfaces veed, as at the lower side of **235** and **236**, there would be a tendency to split the recessed part out. But these joints are well adapted for beams which are subjected to combined tension and bending. As the upper part of a beam is in compression and the lower part in tension, the extremities of the scarf are generally formed, as in **235** and **236**, to suit this, the square shoulder on the upper side being much better for compression. Often short fish-plates are bolted across the under sides to assist in keeping the joint together, and sometimes also across the top joint to stiffen the beam. Sometimes fish-plates the full length of the scarf are employed. Joints in beams should always be arranged to come on or near supports. Fig. **235** is tightened by one key, and **236** by two keys, its form being complicated thereby. For rough temporary work, timbers in tension are often lapped side by side for several feet and bolted.

The tabled and cogged joint [**231**] is adapted for resisting tension. Deeper notches might be employed if it were a joint for tension only, but this would make it weak laterally, and if carried too far, weak in every way. Generally, direct tension in a joint is so slight that the bolts alone can be relied on to resist it. In fished and scarfed joints bolt holes should be bored small enough for the bolts to be driven in a tight fit; and, as in all other woodwork, the nuts should be tightened at intervals as the timber shrinks and accommodates itself to the compressive force of the bolts.

Other Joints. When great lengths have to be made up, a number of deals are often bolted together, breaking joint with each other [**237**]. A very strong timber of unlimited length can be built up in this way. When a great number of deals are employed in this way in forming a single timber, the end joints would not be arranged symmetrically as in **237**, but so that not even alternate ones came opposite each other. The building up of a long timber is only one example out of innumerable instances in which the principle of breaking joint is employed in constructions of wood.



240. KEY FOR BEAMS

Beams may be increased in depth by jointing, as in **238** and **239**, the cogged or serrated joint being necessary to prevent sliding. Iron plates may be employed as in fished joints to increase the strength of a beam. Generally one plate only, called a *flitch plate*, is employed, the beam being split down the middle and the plate bolted between. Steel girders or trussed beams are usually preferred to these methods.

Fig. 240 shows the form of key employed in beams. It consists of a pair of folding wedges which, driven in opposite directions, tighten themselves in a parallel slot.

Continued

ART IN GERMANY, FRANCE & SPAIN

Dürer and Holbein. The Fêtes Galantes. Watteau, Boucher, Fragonard, and Greuze. Hidalgo and Inquisition. Velasquez and Goya

HISTORY OF ART continued from page [illegible]

By P. G. KONODY

German Painters. German painting of the fifteenth century has been admirably summed up by M. Reinach: "Italian art dreamed of beauty and realised its dream. Flemish art was in love with truth and held the mirror up to Nature. German art rarely achieved either truth or beauty. But it succeeded in rendering, with a fidelity that was often brutal, the character of the German people immediately before and after the Reformation." Local schools were flourishing already in the fourteenth century in the various cities and districts, but comparatively few of the artists' names have been handed down to us, and modern research has had to be content in many cases with identifying the painters as "the master of such and such a picture." The schools of Prague, Cologne, Augsburg, the Upper and the Lower Rhine abound in such anonymous masters, who generally contented themselves with setting their angular figures, which in movement and expression often verge on caricature, against a flat golden background, without an attempt at landscape backgrounds, and without much concern for orderly composition. Yet there is an undeniable naive charm in the sincerity of many of these works, though they have neither the beautiful colour, nor the tender sentiment, nor the delicate execution of the contemporary Flemish works.

Dürer. Even Albrecht Dürer (A.D. 1471-1528), the greatest German master, is no exception to the rule, and of pure beauty such as we have met in the works of his contemporaries in Italy but little is to be found in his pictures. He is intensely dramatic and serious, simple and direct, and combines to the highest degree all the qualities that are characteristic of the German Renaissance, a movement which was intellectual and moral rather than artistic [81]. Few, if any, artists could rival Dürer in the rendering of textures, and this refers as much to his line engravings as to his paintings; few could invest every detail and accessory introduced in a picture with more interest; few there are that could depict a simple story with more homely, touching directness.

81. A PORTRAIT. BY DÜRER *Mansell*
(The Prado, Madrid)

Holbein. The second of the great masters produced by Germany was Hans Holbein (1497-1543), the greatest of the Augsburg School, as Dürer had been the greatest of that of Nüremberg. Holbein is one of the few early Germans who is exempt from the charge of lacking the sense of beauty. He benefited by the lesson taught by the Italians as regards pictorial composition, and developed a noble free style which had none of the taint of German ugliness. At the same time he retained the typical German quality of careful, minute observation, tempered by sympathetic insight into character. His portrait drawings, of which a vast number are preserved at Windsor Castle—Holbein was Court painter to Henry VIII.—show his unrivalled sureness of touch and expressiveness of line. Like most northerners, he loved to introduce a great variety of detail into his pictures, but he always knew how to subordinate it to the main theme, which it emphasises rather than detracts from. In such pictures as "The Ambassadors" at the National Gallery [82], or the merchant "George Gyze" at the Berlin Gallery, all the accessories are fraught with meaning, but do not draw our interest from the personages depicted. And for perfect craftsmanship Holbein may be held up to every student as an example worthy of emulation.

Janet. In France the chief representative of autochthonous painting in the fifteenth century was the illuminator Jean Fouquet, but the history of French painting may be said to begin with François Clouet (A.D. 1510-1572), better known as Janet, an artist considerably influenced by the Van Eycks, and one of the

world's greatest miniature painters. His portraits often bear a close resemblance to Holbein's. His contemporary, Jehan Cousin, owed nothing to foreign teaching and acquired great fame as a painter of glass.

Francis I., in A.D. 1531, called Primaticcio and a few other second-rate Italian painters to his country to decorate his castle at Fontainebleau, and this led to the founding of the school of Fontainebleau, from which issued a number of pseudo-Italian mannerists whose pretentious work only delayed the development of national French art. Only, the early seventeenth century brought forth a few native artists of decided originality, notably the brothers Le Nain, painters of homely scenes and of camp life, who had distinct affinity with the Dutchmen of the time, though their sombre colouring connects them with the Spanish school.

The French Classicists. Nicolas Poussin (A.D. 1594–1665) studied in Rome, then considered the fountain-head of all art, and learnt the lessons taught by Raphael and Michelangelo, and even more by the antique. He was more classic than any of the Italian classicists, and his figure paintings are antique reliefs translated into terms of colour. His eclecticism debarred him from seeing life, movement, and emotion in Nature, which, in his pictures, are merely superficial adjuncts to classic poses. But he was a master of the "heroic" landscape, a landscape that is based on noble arrangement and linear perspective, and not on colour and atmosphere. Gaspard Poussin, his brother-in-law, was inspired by Nicolas in his landscapes, though the younger master was a little more concerned with light and air, and not so uncompromisingly severe. The same influence produced the style of Claude Lorrain (A.D. 1600–1682), who is considered in the article on landscape art, and who was an artistic progenitor of the great Turner.

Watteau and the "Rococo" Period. Another pupil of Poussin, Charles Lebrun (A.D. 1619–1690), became Court painter to Louis XIV., and ruled as a veritable autocrat over the art of his country, which degenerated into mere theatrical pathos. He was not only entrusted with all official commissions for paintings, but was made Director of the Gobelins Tapestry Works, and supplied designs for sculptors, cabinetmakers, and metal-workers. His paintings belong entirely to the literary order, and have little to do with art. The real national tradition was perpetuated to a certain extent by the portrait painters Mignard and Rigaud, and, above all, by Antoine Watteau (A.D. 1684–1721), the great painter of the "Fêtes galantes," the typical artist of the "Rococo" period. His arcadian scenes—French courtiers and amorous dames masquerading as harlequins and shepherdesses in delicious gardens—have not a trace of cold classicism, and hold up a faithful mirror to the idle, gallant life of eighteenth-century society. The life he depicts is essentially artificial, but there is nothing artificial in his style. With all their beauty of arrangement, his scenes do not appear to be constructed according to a formula, but have a convincing air of reality; and, above all, he is a painter who revels in the precious quality of the pigment and who allows air and atmosphere to enter into his landscapes. His followers, Lancret and Pater, degenerate into a coarse suggestiveness which is quite in accordance with the immorality of the Court of Louis XV.

82. THE AMBASSADORS, BY HOLBEIN
(National Gallery, London)

Immorality in Art. This tendency reaches a climax in François Boucher (A.D. 1704–1770), the "Painter of the Graces," who is the typical child of a period of degeneracy, though his works, however objectionable they may appear from the moral point of view, have undeniable decorative charm and superficial beauty. His pupil, Fragonard (A.D. 1732–1806), is a brilliant delineator of the nude, an artist of great esprit, who connects the period of untrammelled lasciviousness with the downfall of the old régime brought about by the Revolution. Parallel with this current of art, which is essentially at the service of the Court, is another little stream which reflects the healthier life of the people. Chardin (A.D. 1699–1779) is a painter whose tendency is as decidedly moral and sermonising as Boucher and his school are immoral and seductive. And just as the latter are offshoots of the Italianising classicists, so Chardin is connected with Le Nain and with the Dutch small masters. Even more marked is the moral tendency of some of Greuze's genre pictures [83], though in other works he appears to cater for the sensuality of the ruling classes. But neither

of the two was the founder of a school, and the Revolution directed the art of France into new channels.

French Sculpture. The progress of sculpture in France during these two centuries was very much on the same lines as that of painting. The master who dominates the seventeenth century, Pierre Puget (A.D. 1622–1694), did not receive official recognition, since he would not submit to the autocratic rule of Lebrun. His art was based on the study of the antique and of Michelangelo. The hold of the latter master over Puget appears most strongly in the "Milo of Crotona" at the Louvre. To the eighteenth century belongs Falconet, the author of the very academic equestrian statue of Peter the Great, at St. Petersburg; Clodion, a boudoir sculptor, who expressed in marble and terra-cotta what Boucher and Fragonard expressed in paint; Houdon, a brilliant modeller of portrait busts, and Pigalle, who continued to follow the antique with exaggerated elegance of form. His noblest work is the tomb of the Maréchal de Saxe, in Strasburg. What marks all French sculpture of this period is the striving after grace and elegance and decorative effect, which frequently results in limbs of exaggerated length and a certain dainty affectation, which is far from displeasing. The character of the period is certainly reflected in its sculpture as well as in its painting. But with the advent of the Italian Canova, at the turn of the century, all character was lost in a soulless, cold imitation of all that is merely formal in the antique. The fame of this uninspired marble-carver spread over the whole of Europe, and acted as an effective check to all individual expression. In every country his fatal example was emulated—in Denmark by Thorwaldsen, in England by Flaxman, in Germany by Danneker, and in France by numerous sculptors whose fame has been obliterated by the great men who followed in the second half of the last century.

83. THE LISTENING GIRL, BY GREUZE (Wallace Collection, London)

Spanish Painting. The history of Spanish painting may be said to begin about the time when Granada was captured from the Moors, in A.D. 1492. In no other country was the individual expression so severely handicapped as in this country, where for centuries the Inquisition exercised a censorship which not only forbade the study of the nude and all other "worldliness," but interfered even in matters of detail. The slightest deviation from Scriptural truth or from Catholic dogma was treated as heresy. Thus in painting a "Crucifixion" every artist had to adhere strictly to the measurements of the cross, which had to be in the proportion of 15 ft. by 8 ft.; and the Italian sculptor Torrigiano, who was working in Spain, was actually imprisoned by the Inquisition for having, in a fit of passion, broken up a "Virgin and Child" wrought by his own hands!

Art Under a Shadow. This strict supervision by the Church, together with the serious, proud character of the Spanish race, produced an art of great sombreness and reserve, inspired by a passionate love of reality, an art which has dramatic intensity, boldness, and strength, but never sounds a note of gaiety and joy, and is rarely occupied with beauty and grace. It reflects the proud, hidalgic attitude to life, the grandeza and strict ceremonial of the silent Court, the iron rule of the Church and Inquisition. And through all the influences from abroad from Flanders in the fifteenth century (the Gothic period), from Italy in the sixteenth century, and from France at the close of the glorious period which culminated with Velasquez — can be detected the sombre glow of these national traits.

Juan de Borgoña and Pedro Berreguete, both of whom worked in Castile at the end of the fifteenth century, were among the first to introduce Italian methods, which took firmer root when Charles V. and Philip II. induced a whole band of Italian painters to settle in Spain. Among the prominent Spanish masters of the early sixteenth century are Luis de Morales, Pedro Campaña, and Luis de Vargas, but their works, like those of innumerable other meritorious painters of the period, are practically unknown outside their native country.

The Rise of the Spanish School. What might be called the "historical" period of Spanish art rises with the school of Sevilla, towards the end of the sixteenth century. Pacheco, from whom Velasquez received his early training, was scarcely more than an able Italian mannerist; but Juan de las Roélas (A.D. 1558–1625) and Herrera the Elder (A.D. 1576–1656) introduced something of the sumptuousness of Venetian colouring into the sadness and dark shadows of the Spanish palette. Francisco Zurbaran (A.D. 1598–1662) was a painter of great emotional power, almost ecstatic in his dramatic intensity, with a sense of pleasing form and line.

An extraordinary genius, weird and passionate, was El Greco (1548–1614), who, in his endeavours to escape from the convention and imitation which fettered his precursors, arrived at a frenzied, extravagant style, with figures whose limbs

are twisted into extraordinary contortions and of inordinate length, seen in a patchy light that never was on sea or land. He was a restless spirit, but endowed with a noble sense of colour and with the gift of seeing the dreams of his almost insane imagination as a homogeneous whole.

Velasquez, King of Painters. With Velasquez (A.D. 1599–1660) we reach the apogee of Spanish art. He was not only the greatest master of his time, but opened a new vision to modern art, a vision in which the greatest painters of our own day find salvation. No one has ever more completely realised the truth of the saying that the greatest art is to conceal art. Painted with an astounding sureness and simplicity of means—his palette is said to have consisted of only four colours—his pictures produce an amazing effect of reality. His tone values are perfect, and there is a unity of vision which places before one just what could in real life be taken in by one glance, leaving out such detail as would detract from the general impression, and yet never slurring over anything that is really essential. In his portraits his sitters seem to live in the atmosphere in which they are placed, and their life is not only that of their body, but of the very soul. His psychological insight is the more marvellous, as he painted at a Court where everybody wore habitually a mask of cold dignity to conceal his real character. The realism of Velasquez is of a kind that never stoops to an indiscriminate recording of Nature's accidental blemishes. If his pictures appear to be the spontaneous result of direct observation, and have little in common with the studied arrangement of academic compositions, he is so perfect a master of selection that there is never a touch which would in the slightest degree disturb their quiet harmony and decorative spacing. [See illustrations of paintings by Velasquez on pages 182 and 723.]

Murillo and Ribera. The other name that is inscribed in letters of gold on the tablets of Spanish art is that of Murillo (A.D. 1617–1682), whose pictures have been aptly called the embodied expression of Spanish Catholicism. A charming colourist and accomplished draughtsman, he is wholly lacking in inspiration and depth of thought. He clothed the holy legends in the garments of his period, using the types of the people by whom he was daily surrounded, and thus translated the teaching of the Catholic Church into the vulgar tongue. One of his most familiar paintings is "The Holy Family" at the National Gallery, London [84]. But fascinating as he is at times, he has little to add to the history of the artistic development of his country, or of the world at large. Contemporary with Velasquez and Murillo was Ribera (A.D. 1588–1656), who, trained by the Italian naturalists, became in his turn the paramount influence in the school of Naples. In spite of all that he derived from Italian sources, he always retained the ecstatic passion and the sombre shadows so characteristic of Spain. His favourite subjects were scenes of martyrdom and physical pain.

Mansell

84. THE HOLY FAMILY, BY MURILLO
(National Gallery, London)

Goya the Satirist. With the death of Velasquez and Murillo, Spanish art collapsed as suddenly and completely as it had arisen under their dual star. A brief renaissance of the ancient splendour was, however, brought about by Goya (A.D. 1746–1828), an artist of immense versatility and great genius, though frequently hasty and slovenly in execution. In his best work he almost rivalled Velasquez—in fact, he is the one link that connects this great master with Manet and the later nineteenth century. He must be counted among the greatest etchers and lithographers of all times, as he was one of the greatest satirists, who defied Government and Inquisition with his merciless exposure of the vice, ignorance, corruption, and immorality of his period.

Continued

HERBERT SPENCER & SOCIETY

The Master-Book of Sociology. The Bias of Patriotism. The Sociological Society and Its Work. The Universities and Sociology. Science and Social Life.

Continued from page 3989

By Dr. C. W. SALEEBY

THE book to which we referred at the close of the last article is entitled "The Study of Sociology," and was written by Spencer as an introduction to the whole subject. It constitutes Vol. V. of the International Scientific Series —that magnificent enterprise which Spencer himself had some share in starting—and has been by far the most popular of all its noteworthy successes.

A Book that Must be Read. It is comparatively a small book, and costs only 3s. 9d. Anyone capable of reading anything worth reading can read it. Excepting the little treatise on education it is by far the most popular and readable and attractive of all Spencer's works. Just as no one could regard himself as a serious student of organic evolution unless he had read the "Origin of Species," so no one could regard himself as having made a beginning with sociology who had not read this book. If the reader has time to follow further sections of this course, it follows, *a fortiori*, that he has time to read this book, and we shall assume that he will do so. Our indications of its substance may therefore be brief.

The author begins by showing that we are in need of sociology—an easy task most convincingly performed. He then asks whether there is such a thing as sociology, refuting those who, insisting upon the difficulties of the science, the mutual contradictions of its professors, the incalculable part played in human affairs by the will of man, declare that sociology is impracticable and vain. Among the parallels which he employs he makes good use of that of meteorology. He then proceeds to discuss the nature of sociology and the various difficulties which beset it.

Difficulties of Sociology. The illustrations employed in the course of these chapters will be found the most delightful reading. After thirty years, we may say, perhaps, that the discussion of the intellectual difficulties in the study of sociology will meet, as it did not meet in 1873, with the immediate assent of the great majority of readers. Still more impressive is the discussion of the emotional difficulties which beset us—a discussion which includes a noble and terrible indictment of those who worship the incomparable criminal whom men call Napoleon the Great. Here we may note that Spencer refers to the estimate that "one vile man's lust of power was gratified through the deaths of two millions." The recent estimate made by a great living Frenchman, however, places the figure at eight millions. The present writer would be only too pleased if he could send to each of his readers a copy of this volume containing all the annotations that he has made in his own copy; but this one, at least, he cannot forbear quoting.

Morality and Patriotism. Spencer then goes on to discuss the difficulties which may all be classed as bias. He describes the educational bias which, alas! is as bad to-day as it was a generation ago, and which continues effectively to blind our legislators. Then follows a chapter on the bias of patriotism, which distorts so many of our views and which often expresses itself in the abominably immoral sentiment, "my country, right or wrong." This chapter concludes with many admirable pages upon the bias of anti-patriotism, which, of course, is not nearly so common nor yet so dangerous, but unfortunately vitiates the social and political judgments of some of the finest souls in our midst. We recommend this chapter to every reader who thinks, or thinks there is any chance of his ever thinking, about things that matter. Equally important is the chapter on the class bias, which, like the whole book, is filled with such admirable sayings as these: "It will become a matter of wonder that there should ever have existed those who thought it admirable to enjoy without working at the expense of others who worked without enjoying." Next comes political bias, quite the least excusable of all forms of bias, and then a great chapter on theological bias and anti-theological bias, the wisdom of which, if listened to, would wipe out the columns of imbecilities that constitute reports of speeches on the Education question

The Sociologist's Intellectual Training. Not with reference to sociology alone, but with reference to all objects of study and belief, we will venture to say that the reading of these pages (178 to 313) on bias must establish an epoch in the development of any mind that is a living thing and not a mere sensitive plate. They will make fair-minded, or as fair-minded as one may be, any one who tries to be fair-minded, and they will at least make ashamed of himself in his heart of hearts anyone who does not.

Lastly, the author considers the intellectual discipline necessary for the sensible and worthy study of sociology. Previously, as the reader will observe, he has considered the moral discipline which will make the student's mind fair and worthy—the author rightly regarding the importance of this discipline as prior to that of any merely intellectual training. The author shows how this intellectual training must include an acquaintance with the principles and practices of the fundamental sciences, ever strengthening in the mind the ideas of relation and cause and effect. Subsequent sciences, such as biology,

will prepare the student's idea of causation for the demands which will be made upon it by sociology, in which causation is not only *continuous* but almost appallingly *complex,* and *contingent* upon so many factors. There follow important chapters upon special preparation in biology and psychology—such, it may be hoped, as the reader has had—and then the work is brought to a conclusion.

The Sociological Habit of Mind. Our estimate of the book is that which is commonly entertained by sociologists in all countries, and we earnestly hope that what we have said will compel our readers to acquaint themselves with it. Having done so they will find themselves not only far more interested in sociology than they were before, but also able without effort to look at things from the sociological standpoint. In short, to read this book is to acquire the sociological habit of mind ; nor is there any other means by which this may be so readily or so well acquired. Having read this book the student will welcome a brief account of its illustrious author—an account which we shall try to make consonant with his own conception of the value of personalities and of the right kind of biography.

It would be fair to say, perhaps, that the modern rational view of history in general regards it as a combination of descriptive sociology and scientific biography. Thus, to choose extremes, the geographical view of history and the great-man theory of history may take their due places in that comprehensive view which will be completely true.

The author of the doctrine of universal evolution was born in Derby in 1820 and died at Brighton in 1903. In his voluminous autobiography he discusses, in scientific fashion, all the facts of his ancestors which could throw a light upon his own mental characters. It is quite plain that he belonged to an exceptional stock, the most noteworthy character of which was independence of thought.

Herbert Spencer's Greatest Achievement. Spencer, of course, was predestined to be a thinker from the first, but it was not until he was forty that the great work of his life was begun. Before that time he had written some remarkable essays, including the famous short paper in which he upheld the nebular theory against all the astronomical authority of the time, and the essay called "The Development Hypothesis," in which, in 1852, seven years before the publication of the "Origin of Species," the young author argued for the truth of the doctrine of organic evolution. Reference has already been made to the epoch-making "Principles of Psychology," which appeared in 1855. The great achievement of Spencer's life was, of course, the Synthetic Philosophy. This is not merely the only philosophic system that any Englishman has given to the world, but—which is immeasurably more important—it is regarded as substantially true by those competent critics who are acquainted with it.

The doctrine of the synthetic philosophy is that the principle of evolution—this word having been introduced by Spencer in 1857—is the key to the problems of all phenomena. The Synthetic Philosophy consists of "First Principles" (recently published in a cheap edition by Williams & Norgate); "Principles of Biology"; "Principles of Psychology"; "Principles of Sociology"; "Principles of Ethics." The aim of the entire system was to establish the truths of morality upon the "solid ground of Nature," and, as the author became an old man, he feared that he would never reach the "Principles of Ethics" if he wrote his work in the logical order. He therefore passed at once to this final subject, but fortunately lived to return to the "Principles of Sociology," the last volume of which was published in 1896—thirty-six years after the inception of this magnificent enterprise.

What We Owe to Spencer's Inspiration. Spencer is undoubtedly greater as a biologist, a psychologist and a moralist than as a sociologist. This, however, is not to say that his sociological work is not of the utmost importance. Many of his conclusions, however, like those of his predecessors, are invalidated by the inadequacy of the facts upon which they were based.

If the history of science proves anything it is that there is no royal road to generalisations, and sociology was yet too young for Spencer and his contemporaries to do the work which they attempted. This we must recognise, even though we admit that the main lines of his conclusions were sound, and, pre-eminently, that his method and his conception of sociology, as dependent upon biology and psychology, were true and fruitful. Lastly, sociologists must pay him tribute as having done far more than anyone else in his time to disseminate the idea of sociology, to teach thinking people that there is or may be such a thing, to arouse their interest, and to inspire the labours of thousands. Largely to such inspiration do we owe the fact that the sociological material at the disposal of the student is multiplying manifold with every decade and that the voice of trained thinkers is beginning to be heard even where politicians most do congregate.

The Sociological Society. During the last few months of Spencer's life a few ardent students determined to form a Sociological Society in this country. Owing to the generosity of many persons, and especially of Mr. Martin White, whose name is well worthy of honour, this project was realised, and on November 20th, 1903, there was founded, less than three weeks before the death of the great philosopher, the Sociological Society, which is beginning to count for something in English thought and has already done much for two great complementary studies of the first importance—Eugenics and Civics—which we shall afterwards have to consider. Some interest attaches to the fact that the first president of this society, the Rt. Hon. James Bryce, is now a Cabinet Minister. One wonders what some Cabinet Ministers of the past, such as Palmerston, with his "damned professors" and his ignorant hatred of anything like knowledge or learning, or the philosophic

temper, would have made of a meeting of the Sociological Society. Mr. Bryce has been succeeded by Lord Avebury. To the sociologist who approaches the science, as we are doing, from the more fundamental sciences, especial interest attaches to the presence of Lord Avebury in the presidential chair of this society. In the first place, it is significant that sociology should demand the services of a historian like Mr. Bryce on the one hand, and a biologist like Lord Avebury on the other. But it is particularly noteworthy that Lord Avebury symbolises the existence of the science which we may here venture to call *Comparative Sociology.* To this subject we must devote at least a brief study.

Human and other Societies. The use of the term *comparative* is well recognised in all departments of the sciences that deal with living things. Comparative anatomy takes a wider view of anatomy than mere human anatomy. It deals with the anatomy of all animals, with a special eye to discovering the comparisons between the body of man and the bodies of the lower animals. If the doctrine of evolution means anything at all it must certainly mean that one cannot truly understand human anatomy without studying comparative anatomy. The same is, of course, true of comparative physiology. We are just discovering that it is most conspicuously true of pathology and comparative pathology. A whole host of the most important diseases, which the study of man alone would never have elucidated, has already yielded or is rapidly yielding to the science which compares disease processes in man, monkey, and mouse. Yet, again, the importance of the comparative method is demonstrated in the case of psychology. Spencer, as we have seen elsewhere, was the first comparative psychologist, the first thinker to abandon the false and proud attitude which assumed not merely that the psychical characters of the lower animals had no relation to, and no bearing upon, the mind of man, but even that the minds of savages, the minds of children, the minds of Orientals, the minds of women, needed no study and, presumably, had nothing to do with the particular mental characters of the adult Caucasian man—characters to which all psychologists hitherto had been complacent enough to attribute the magnificent term *Mind.*

Social Instinct in Animals. Nor does the comparative method fail us when we come to sociology. When we speak of a school of whales, a shoal of fishes, a herd of deer, when we see the flight of birds across the sky, each bird falling into its own place in rank or file—in all such cases we recognise, though we may never have thought about it, that the social instinct is not peculiar to man. We shall afterwards see that the unit of society—or at least of all the higher forms of societies—is the family, and wherever there is the family there is at least the germ of a society. Now, the lower animals also show the existence of the family in many cases. Furthermore, there may be suggested the generalisation, which the present writer is prepared to uphold, that the form of the family—the word being here used in its widest sense—will determine the form and the fate of the society. Where there is no family, as in the case of nearly all the fishes, the society can never reach any but the most rudimentary form. Where the family is that dependent upon polygamy, a human society—for instance—will differ in form and fate from that the unit of which is the monogamic family. Again, where the family—if family it can be called—is so vastly different, as in the case of the hive bees, there the resulting society will be totally different in form and in potentiality.

The "Sub-Human" Societies. The comparative study of societies, then, or the comparative study of the family, must be of the greatest interest to the sociologist. And of all the sub-human societies which interest him none can for a moment approach in interest, in complexity of organisation, in wonder, in strangeness, and in significance, as well as in respect of the immeasurable gap which separates them from us, *the societies of the social insects.*

Now, of these Lord Avebury is, as everyone knows, not only the greatest living authority, but the greatest authority of any time, and thus a very especial interest attaches to the official connection of the greatest student of sub-human society with the society that exists to study human society. It is now earnestly to be hoped that Lord Avebury may consider the desirability of adding a volume of "Comparative Sociology" to his already great record of literary work. It would be a pity if some student of the subject whose knowledge is less profound is compelled to do this piece of work, which, it seems to the present writer, urgently demands doing.

Sociology and the Universities. Though there are six official teachers of sociology in such a place as Chicago, and though Brussels, for instance, has its magnificent Institut Solvay, founded by a man of wealth and wisdom, it was not until the end of the year 1904 that sociology obtained its first recognition in any university in the land of Spencer. The recent recognition of sociology as an academic subject by the University of London—which has hitherto been followed by no other university—is due to the work of the Sociological Society and the generosity of Mr. Martin White. Since that first step was taken there has also been removed the reproach that there was not a single recognised teacher of sociology in this country. It is true that this mighty and dominating science is yet unrepresented by a Chair in any of our universities, including even the recent provincial universities, from which such great work will surely spring, and including even the University of London, which is at last beginning to become a reality and not a name. But, at any rate, the University of London has instituted a lectureship—one solitary lectureship—in sociology, and has appointed to it one of the very greatest of living thinkers—Dr. Westermarck. It is significant that the first official teacher of sociology in this country should be a foreigner. Dr. Westermarck is known throughout the civilised world as the greatest authority upon

marriage—perhaps the only social institution that is worthy of the title fundamental. Since leaving his native Finland for this country, Dr. Westermarck has been at work upon an aspect of the evolution of ethics which is entirely new, and quite distinct from the wider conception of the evolution of ethics, which we owe, of course, to the apostle of evolution himself.

Moral Ideas. In his book on "The Development of Moral Ideas," Dr. Westermarck concerns himself not with the gradual evolution of morality from parentage and from sympathy, but with the actual history, so far as it can be ascertained, of the production and growth of moral ideas among the lower races of man—many or most of which, of course, when judged by true ethics, are immoral ideas; and he is continuing his study of this subject up to the highest places. The moral ideas with which he is concerned are, of course, quite distinct from the true morality, which is grounded in love alone, but conforms more to the derivation of the word morals, which, of course, means merely customs. These ideas, and the customs based upon them, have, however, played a gigantic part in the history of society, and very notably in the history of religions. It is something that this great work is being done, though not by an Englishman, at any rate by the first academic sociologist in this country, and on English soil.

The different standpoints from which sociology may be looked at are many and various. It is unique amongst the sciences in this respect. Every man's conception of sociology differs from his neighbour's conception. The ecclesiastic, the psychologist, the physician, the biologist, the social reformer, the moralist, and the detached student of the sciences in general—all these have their own points of view. Again, a man and a woman cannot possibly look upon sociology with the same eyes. Here, however, we have no space in which to discuss "the relations of sociology to the social sciences," or, indeed, what may be called the philosophy of sociology.

There are two leading considerations, however, which it is impossible to omit from our introduction to the subject. In the first place, we must refer briefly to the relations of sociology to the sciences that are beneath it, and then we must consider its relations to the one supreme science which is above and beyond it.

The Foundation of the Sciences. There is an aspect of sociology on which it is well that we should insist. The science has often been described as the crown of all the other sciences, and so, of course, it is. One readily understands how a complete sociology would include within its substance the whole tissue of, say, physics, biology and politics alike; but, on the other hand, the present writer is coming more and more to be impressed by the significance of another view of sociology—that which regards it as not so much the crown as the foundation of the sciences. Instances may easily be adduced. For some years the writer has thought, written, and spoken about infant mortality as if it were a medical problem. He has sought to eliminate heredity from its causation in any marked degree, and to attribute it to bad feeding and the like. It is only after reading Dr. Newman's recent book on the subject, which he describes as a *social problem*, that the present writer has realised how partial his analysis of the matter has been. It now seems self-evident to him that this is not a medical problem, but a social problem.

Drink is Society's Problem. Or, again, take the question of alcohol. In this case, as in the last, the medical sciences have done their work. The alcohol question was once, perhaps, a medical problem; it is so no longer. On the contrary, medicine can hand it over to sociology, and say: "This is your affair; what are you going to do about it?" Or, yet again, take the question of the provision of meals for school-children. Here, again, the medical problem is easy, soluble, and solved. The medical man knows how minute are the sums on which a child may be adequately fed. He knows how constantly these and larger sums are spent on that which is not bread.

The working-class family in this country spends on the average one-sixth of its total income on alcohol, as Messrs. Rowntree and Sherwell have proved. The problem of the physical state of these school-children is not to-day one for physiology or medicine, and is not to be solved once and for all either by medical inspection or by the most scrupulous obedience to the science of dietetics in the provision of school meals. In reality it is a question for the sociologist, and its solution will depend, the present writer believes, upon the answer which is returned to the question: "What is the unit of society—the family or the school?"

"The Causes of the Causes." These instances are typical. It is evident that the subordinate sciences, such as medicine and biology, have their place. It might also be proved readily enough that these sciences must be incorporate in a perfect sociology; but it is also evident that these sciences alone are impotent to cope with the questions which at one stage have to be referred to them. Faced, for instance, with "physical deterioration," they are able to analyse it, define it, and indicate its "causes"; but—and this is the essential thing—*the causes are only proximate causes.* We who believe that the universe is a universe know that causation is universal and eternal, and that of any causes of anything the philosopher must ask: "What are the causes of these causes?" For years the writer has contented himself with asserting and animadverting upon the merely proximate and medical causes of infant mortality. He thought that one had merely to make these causes generally known to abolish the evil. Now, however, Dr. Newman has taught him, what he should not have needed to be taught, that these causes, though valid and essential, are only links in a chain which is endless, but the most essential links of which are not medical, but *social.*

Continued

METAL-RECOVERY FURNACES

Classes of Metal-recovery Furnaces. Copper Ore and its Recovery. Copper Roasting. Electrolytic Copper

Continued from page 3942

By A. H. HIORNS

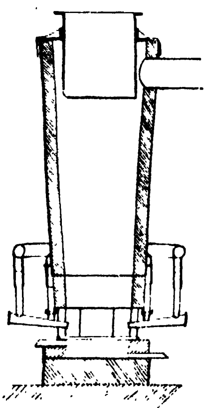
A HEARTH, forge, or furnace is a structure in which ores and metals are submitted to high temperatures. A furnace is usually constructed of refractory material on the inside, and of iron or ordinary brick on the outside. Furnaces may be divided into three classes: (1) those without an independent fireplace, such as a blast furnace and a hearth; (2) those with an independent fireplace, such as a reverberatory furnace; (3) those in which the material is separated both from the fuel and from the products of combustion, such as a zinc retort. They may be used with a natural draught, the air being aspirated by means of a chimney, or the air may be forced in by means of a blowing apparatus. In both cases the heat developed depends on the calorific power and weight of fuel burnt in a given time; also on the mode of combustion, for if the combustion be complete, the whole of the heat may be utilised.

Hearths. A hearth is a low furnace in which the material to be operated upon is mixed with the fuel and flux. The heaps, stalls, and certain kilns for roasting ores are included under this title, as the fuel and ore are mixed, and the action is the same. The smith's hearth is a familiar example of this type.

Shaft Furnaces. A shaft furnace, commonly called a *blast furnace*, is a structure with the long axis vertical, and contains one common receptacle for the materials employed. Certain of them, as the kilns in which limestone or ore is calcined, are worked by a natural current of air, the furnace forming a large chimney. The forms of blast furnaces are very varied, according to the nature of the ore and fuel used. They may be egg-shaped, cylindrical, or conical. In roasting iron ores, for example, where a large mass of material has to be expeditiously treated and where only a moderate temperature is needed, the diameter is greater in proportion to the height than in furnaces used for the reduction of ores, in which case the height may be from three to five times the diameter, because it is necessary to have a high temperature in the region where the fuel is largely consumed, and the more fuel there is burnt in a given space in a given time, the higher will be the temperature. The fuel employed may be coal, coke or charcoal, because oxides or materials which have been oxidised by roasting are generally treated in this furnace.

In the case of raw coal, it is decomposed in the upper portions of the furnace, so that by the time it reaches the zone of combustion it is in the form of coke.

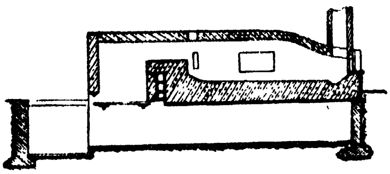
Shaft furnaces for reducing ores are supplied with a forced blast, and may be theoretically divided into three parts: (1) the upper portion, where the ore is partly reduced without melting, the volatile matter is expelled, and raw coal is converted into coke; (2) the middle portion, which may be considered neutral, because the carbon dioxide formed by the reduction of metallic oxides in the lower part of the furnace neutralises the reducing gases; (3) the lower portion, where the temperature is very high and the atmosphere completely reducing. In the last, flux and earthy matters unite to form a fusible slag; the metal is liquefied and falls to the bottom of the furnace, the slag floating on the top. Fig. 26 is an example of a blast furnace used for lead smelting. It is formed of two independent parts—the *body* or *stack*, which is supported on iron pillars, and the *hearth* or *crucible*, which is surrounded by a double iron casing, through which water is made to flow in order to keep it cool. The blast is supplied through six or eight twyers. The throat is closed, except while charging, by a cylinder, and the waste gases are carried off by a side pipe.



26. BLAST FURNACE FOR LEAD SMELTING

Reverberatory Furnaces. A reverberatory furnace is distinguished from the former types in being arranged with the long axis horizontal, and in having an independent receptacle for the fuel. The fireplace is separated from the bed, or *laboratory*, as it has been conveniently called, by a fire-bridge, which is simply a wall of refractory brick, usually furnished with an air channel to keep it cool, and sometimes provided with orifices which admit air into the furnace. At the chimney end there is generally another bridge, termed the *flue-bridge*. The chimney is connected with the laboratory by a flue of varying length, and more or less horizontal. The chimney serves the double purpose of producing the draught and of carrying off the waste gases. The roof generally slopes downwards from the fireplace to the chimney, so that the flame may be reverberated on to the material on the bed. The size of a reverberatory furnace is determined by the kind of material to be operated upon. When ores are simply roasted, the length may be many times that of the fireplace, but when a high local temperature is desired, as in the

case of puddling iron, the bed is not more than two to three times the area of the fireplace.

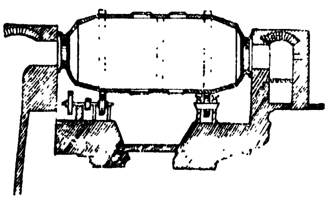


27. REVERBERATORY FURNACE FOR REFINING COPPER

Fig. 27 is an illustration of a reverberatory furnace used for refining copper.

Types of Reverberatory Furnaces. In cases where the temperature need not be very high, as in the calcination of ores, the bed is built of common firebricks ; but in copper-smelting furnaces the bed is formed of two feet of sand rammed in tightly, and in puddling iron the bed is coated with a thick layer of oxide of iron and iron slag rich in oxide of iron. The most important reverberatory furnace in which gaseous fuel is used is the regenerative open-hearth furnace of Siemens. The great advantage of this type of furnace is that a reducing, neutral, or oxidising atmosphere may be obtained at will by regulating the supply of air.

The Bruckner Calciner [28] is a special type of reverbetraory furnace used for roasting silver and copper ores. It consists of an iron revolving cylinder, lined with firebrick, about 8 ft. in diameter and 15 to 20 ft. long. At one end is the fireplace and at the other end is a dust chamber connected with the flue and chimney. The cylinder rests on friction rollers and is rotated by gearing placed on the exterior.



28. BRUCKNER CALCINER

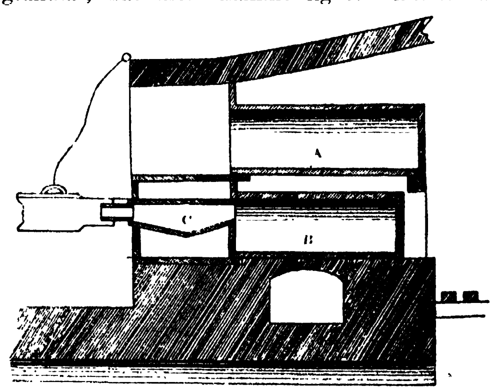
Closed Vessel Furnaces. In this class of furnace the material to be heated is separated from the fuel by an envelope, in the form of a closed vessel. The vessel is heated by being in contact with the fuel or with the flame developed by the combustion of fuel. The form of the vessel is determined by the work to be done. Thus, for simple heating, the muffle is employed, while for fusion, crucibles are used. For distillation and sublimation a retort is used. The ordinary brassfounders' furnace may be taken as a type of crucible furnaces, and the zinc retort as a type of retort furnaces. Fig. 29 is a section of a Belgo-Silesian zinc furnace. Two retorts (A, B) are shown one above the other ; in these the zinc ore and carbon are placed, and the flame playing round them produces the necessary heat for the reduction of the ore. The vaporised zinc is condensed in the receivers, C, placed in front and attached to the retorts.

Production of Draught. Natural draught is produced by means of a chimney, which may be regarded as a vertical pipe containing heated and expanded gaseous products of combustion. The column of air in the chimney is lighter than the air of the same height at the ordinary temperature. Hence, there is an upward movement owing to the difference of weight, and as the air has to pass through the furnace, the draught will depend on the temperature of the fire in the fireplace, because the higher the temperature the more rapidly will the gases pass through the chimney, and a greater weight of air will be required to replace these gases per second.

Forced draught in small hearths is produced by bellows, but for smelting furnaces, blowing cylinders are generally used. In the simple melting of metals and in some small blast furnaces a rotatory fan or blower is largely used.

Hot Air. When hot air instead of cold air is supplied to a furnace the temperature of combustion is considerably increased, and as the waste heat of a furnace may be utilised in heating the air a great economy is effected by its use. A description of arrangements for heating the blast of air supplied to blast furnaces is given in the course on Iron Manufacture.

Copper. The metal copper has been known from the earliest times, because it is found in the earth in the metallic state, and its oxides are easily reduced. It has a red colour and brilliant lustre ; it is highly malleable and ductile, so that it can be rolled into thin sheets and drawn into fine wire. At temperatures near its melting point it is brittle, and may be readily powdered. The tenacity of cast copper is about 8·5 tons per sq. in. It melts at a temperature of 1,080° C., and is not sensibly volatile. Its specific gravity is 8·82. The fractured surface of pure copper is of a fine salmon-red colour and finely granular, but after hammering it exhibits a somewhat fibrous fracture, with a silky lustre. The conductivity of copper is very high, but is considerably reduced by small quantities of certain impurities. Of the impurities likely to be present, bismuth is the most injurious ; antimony, arsenic, iron, tin, phosphorus, and manganese, also largely interfere with this property.



29. BELGO-SILESIAN ZINC FURNACE

Copper is unacted on in dry air at ordinary temperatures, but rapidly oxidises at a red heat. In moist air it acquires a coating of carbonate. It forms with oxygen both cuprous and cupric oxides.

Native Copper. The ores of copper are: Native copper, of varying degrees of purity; *cuprite* or red oxide (Cu_2O); black oxide (CuO); copper glance (Cu_2S); copper pyrites (Cu_2S Fe_2S_3). Grey copper ore is a mixture of the sulphides of copper, arsenic, antimony, and iron. Blue and green carbonates, known as *malachite* and *azurite*, are composed of $CuCO_3$ and CuH_2O_2 For smelting purposes, copper ores may be classified as oxides and sulphides. The most abundant and poorest ore of copper is pyrites, since the iron and copper occur in almost all proportions from a trace of copper up to 56 per cent., as in peacock ore. Copper is extracted by both dry and wet methods. The dry method is further classified into *reverberatory* and *blast* furnace processes, although the main principle is the same in each case.

Copper Extraction The Welsh or reverberatory method was formerly conducted in six or eight stages, according to the richness of the ore, which is chiefly pyrites. The process consists of alternate roastings and meltings in order to oxidise the impurities and pass them into the slag, while the copper is concentrated as a regulus or sulphide. When this concentration is considered sufficient, the copper sulphide is partially roasted, so as to form a mixture of oxide and sulphide. Then these are allowed to react on each other at a higher temperature, and liberate the copper in an approximately pure condition. This reduced copper is refined in a special reverberatory furnace [27]. The cakes of copper are gradually melted, during which oxides are formed, including the impurities. These oxides unite with silica (sand), and form a rich slag. The metallic copper is covered with anthracite and a pole of wood is inserted. The carbon and gases from the wood reduce the oxides of copper, and bring the impurities to the surface. If the poling is insufficient, the copper is dry in appearance and brittle. When the right degree of poling is attained, the copper is said to be at "tough pitch." If the poling is carried too far, the oxides of the impurities are also reduced and pass into the copper, making it brittle. Another method of refining copper, largely practised in America, is by means of electrolysis. It is cast into slabs, placed in a copper sulphate solution, and a current of electricity passed through until the copper is deposited. Such copper is remarkably pure.

Copper Reduction. In the blast furnace methods, the roasting is often done in heaps or kilns, but the more modern plan is to use large revolving cylinders or large fixed chambers, in which the charge of ore, or regulus, is automatically stirred and carried forward by mechanical arrangements. The blast furnace for copper extraction is generally built of iron, tapering slightly, so that the top is wider than the bottom. The iron casing is double, with a space between, so that water can circulate through in order to keep down the temperature. The regulus collects in a special receptacle called a *fore-hearth*, and is withdrawn when desired. Brick furnaces are also extensively used. The regulus, or matte, is again roasted, so as to form oxide, and the oxide is reduced by carbon in a second blast furnace treatment. The refining is the same as in the Welsh method. The blast furnace process differs, therefore, from the reverberatory process in that the oxide is finally reduced by carbon, and not by reaction between oxide and sulphide.

The Bessemer converter is now largely used for obtaining copper from regulus (sulphide). The blast of air oxidises the sulphur, forming sulphur dioxide gas, which escapes, and partially oxidises the regulus. The oxide and sulphide then react on each other, producing metallic copper, as in the Welsh method. The *wet* process of copper reaction depends upon the principle that a solvent first dissolves the ore, which passes into solution, and the copper is then precipitated by means of iron. The precipitate is finally refined.

Electrolytic Copper. The application of electrolysis to the refining of crude copper, referred to above, has greatly increased of late years. If a current of electricity pass between two copper plates immersed in a solution of sulphate of copper, the anode rapidly dissolves, while an equivalent weight of copper is deposited on the cathode. If, then, an impure plate of copper be used as an anode, the copper will be dissolved, and with it some of the impurities, but so long as there is a good excess of copper present, and the right strength of current is employed, the copper alone will be deposited. Bismuth, tin, antimony, and arsenic remain in part insoluble; platinum, gold, and silver are left on the anode as a slimy deposit. The crude copper is cast into slabs, which are suspended one behind the other in lead-lined vats, all of them being connected with the positive pole of the generating dynamo. Alternately with them are hung thin sheets of pure copper, which are connected with the negative pole and on which the pure copper is deposited.

The varieties of commercial copper are: Cement copper, Japan copper, cake and ingot copper, bean short and feathered shot copper, electrolytic copper, and best selected copper.

Continued

CHEMISTRY AND THE WORLD

The Chemists and the Great World-Problems. The "Beginning" of the Universe. Can We Make Radium? "All Flesh is Grass." Our Universal Ancestor

By Dr. C. W. SALEEBY

THERE is absolutely no limit to the variety or the number of organic compounds. We are acquainted with merely a fraction of those that occur in Nature, and we are capable of making as many more as we please of compounds which we have every reason to believe do not occur in Nature at all. To these latter products we can make no detailed allusion here, but it is necessary, at least, to point out their importance and to convince the reader of it, though he hears little about them in this place.

Most Fascinating Branch of Chemistry. Synthetic chemistry, which is now, with the exception of radio-activity, the most fascinating branch of the science, is daily making very rapid strides, notably under the influence of Professor Emil Fischer, of Berlin. Its difficulty can only faintly be imagined by the elementary student. If we were to discuss it here in proportion to its importance, we should need scarcely less space than this course has hitherto occupied. Here, however, we must try to gain clear notions as to the two distinct and equally important directions in which synthetic chemistry is advancing. When these have been discussed, we must also consider a third direction in which as yet no advance whatever has been made, but which in time may overshadow both the others.

One definite direction in which synthetic chemistry is advancing, so fast that even those who devote their whole lives to this particular branch of our subject can scarcely keep abreast of it, is the manufacture by synthesis of entirely new chemical compounds of carbon. The object of this branch of synthetic chemistry is largely theoretical, but perhaps mainly practical. In the first place, let us consider its theoretical interests.

The Achievements of Synthetic Chemistry. The chemist believes that law governs the behaviour and properties of all chemical compounds. He is acquainted in Nature with a number of organic series, such as the paraffins and their derivatives. It is thus one interest of his to see whether he cannot form artificial series which still display the serial quality. Furthermore, he tries to elucidate the relations of one series with another; and he tries to account for the properties of various series, and for the variations in the properties of the successive members of any series, in terms of molecular constitution. It need hardly be said that the facts which he thus discovers—having first, in a sense, made them—are of the very greatest importance in the study of the compounds which occur in Nature.

The second interest of this branch of synthetic chemistry is practical. We have already seen one of its practical issues, with which the name of Sir William Perkin, the great Englishman who has enriched the wise Germans, will always be associated. But we may venture to say that the manufacture of artificial colours is one of the least of the practical results of this branch of chemistry. Far more important in these days are various developments which more directly concern human life. Of these the best instance is furnished by the modern synthesis of drugs, which has already achieved the most remarkable successes. This subject can be dealt with here only by means of one illustration.

The Search for an Ideal Hypnotic. We have already seen in our study of the alkaloids two powerful substances which are capable of causing sleep, and to these many more might be added; but hyoscine, though irresistible, is an extremely dangerous drug. The patient will certainly sleep, but there is the risk that he will never waken. Morphine, again, though it is still absolutely indispensable, is attended with many grave disadvantages, as the reader knows. Now synthetic chemistry has turned its attention to this question of the production of an ideal hypnotic. It is doing the same with respect to the ideal antiseptic, the ideal anæsthetic, the ideal antipyretic, or febrifuge, not to mention many other kinds of drugs. In the case of the hypnotics, its efforts have been very successful, and for some time past every few years have seen a definite advance. This advance becomes the faster because the chemist is aided by the study of the molecular constitution of his previous products. He finds, for instance, that a certain compound will cause sleep, but has very little effect in relieving pain. On the other hand, he is acquainted with another compound, perhaps, which does not cause sleep, but will markedly relieve neuralgia, and thus, of course, may indirectly cause sleep. He compares these drugs with each other and with many of their fellows, and is more or less able to recognise the particular part of a given molecule that has a particular action upon sleep or pain or fever, or whatever it may be. He then tries, so to speak, to piece these various parts together in various combinations for various purposes. Let us briefly glance at some of the results.

The Survival of the Fittest. The chemist has added the substance called *paraldehyde* to the list of hypnotics, this being a polymer of acetic aldehyde. Again, we have already referred to chloral, and now we may note the existence of a really valuable hypnotic called *chloralamide*, which is a compound of chloral and formic acid. These, however, are not to be called synthetic products, perhaps, in the same sense as a number of other hypnotics, of which the best known is called *sulphonal*. This

substance has a well recognised formula, and may be regarded as methane, the hydrogen atoms of which have been replaced by ethyl groups and methyl groups, together with an oxide of sulphur. For some time sulphonal ranked as one of the best of all hypnotics for certain purposes. It was very widely used, and sometimes unfortunately abused. Then it was found that a modification might be made in sulphonal by the insertion of three ethyl groups instead of two in the molecule; or four ethyl groups might be inserted. The substances thus formed are known as *trional* and *tetronal* respectively. Of these the first, trional, is in every respect without exception markedly superior to sulphonal. If trional had been discovered first and sulphonal later, no one would dream of employing sulphonal to-day. In course of time the diethyl compound will be entirely superseded by the triethyl compound. The tetraethyl compound, *tetronal*, is dangerous, and should not be used.

And now it appears that, directly in consequence of a research initiated by Fischer, trional itself will have to be superseded and replaced by a new synthetic product called *veronal*, which, for a very large number of cases, may be looked upon as, at any rate, all but the ideal hypnotic. This last drug is, so to speak, an instance of the survival of the fittest. During the last ten years the number of possible hypnotics of synthetic origin must have reached scores. As each new one comes out its effects have to be tried, and it is only now and again that one is found capable of replacing the drugs already known.

What the Chemists are Learning. Both in this case, however, and in the case of the production of artificial scents, colours, and other products, the purely experimental method is yielding to something of a higher scientific order. At one time the chemist worked almost in the dark; he began with some suitable substance, such as benzene, perhaps, and then tried to fit various atoms or combinations of atoms on to it in the hope that "something would turn up." Now, however, this purely empirical method is being superseded. Chemists are learning, as we have seen, not merely that there is a necessary relation between molecular constitution and physical action, but also what the exact relation is in a number of cases, and so now the work can be done more methodically. Time need not be wasted by the mere manufacture of one compound after another—its novelty being the first consideration, but the chemist can work in definite directions, keeping firm hold, so to speak, of molecules or radicles which he knows to be valuable, and aiming only at the production of new molecules in which those properties will be retained.

So much by way of illustration; but we try to number ourselves, readers and writer, among those who, as Spencer puts it, "search for the wider meanings of facts," and we cannot leave this subject without reference to what we may call the philosophy of it. If we venture to employ such a daring term as *creative chemistry*, or to speak, as has elsewhere been done, of "the chemist as creator," we must inquire into the meaning of that term.

Nature is Commanded by being Obeyed. In a great epigram which we have quoted more than once, Bacon has summed up all the facts of the case and more. "Nature is to be commanded only by obeying her." Now, words like creative and creator may legitimately be applied to man in many of his acts. A great musical composition—such as, let us say, the third or fifth or seventh symphonies of Beethoven, or even a simple folk-song, may properly be called a human creation; so, also, is a chair, a house, or a football; so, also, is "Paradise Lost." Man may be looked upon as the creating animal.

Now what does the word mean? We who are students of science clearly recognise what the word does not mean. First, the chemist or the poet does not make something out of nothing, and, in the second place, whatever he makes, does, or creates, he remains the servant of Nature, to use Bacon's phrase, as well as her commander. The greatest genius cannot modify by a hair's breadth the smallest of Nature's laws. Not in this sense can Nature be commanded, and not in this sense can man create; but if man choses to observe Nature's laws, to obey Nature, then he can command her in this limited sense. Thus the synthetic chemist will fail, and continue to fail, if he tries to make compounds in defiance of Nature's laws. If it be a fact of Nature that carbon and oxygen have an affinity for each other, there will never be any making of a compound which depends for its existence upon an antagonism between those two elements. If, on the other hand, the chemist will accept Nature's laws, then his intelligence is capable of directing them to his own purpose, and so producing new compounds which Nature herself would not have made, but which yet are made in obedience to her. This saying of Bacon's is one of the profoundest that ever emerged from a mighty mind.

Natural Law and Creative Works. Or turn from chemistry to poetry, or music, or art in general. There are artists in all ages and in all kinds of art who have never had a glimmering of the truth which Bacon stated. They think that they can create works of art without any reference to Nature. They think that they can use pigments, or sounds, or human emotions—which are all natural products—and create works of art therefrom without any reference to the laws of chemistry, the laws of vision, the laws of acoustics, or the laws of psychology. Contemporary musicians might be named, and poets and painters, who think that because they did not defy Nature, Beethoven and Wordsworth and Velasquez were not great men and were not creators. But these mighty geniuses did not set up their puny wills against the laws of the Universe; they obeyed Nature; they obeyed her so well, and loved her so well—Wordsworth says that "Nature never did betray the heart that loved her"—that she allowed them to command her, and so they produced works of creative art which can never die.

The same is strictly true of every kind of scientific invention and creation, as well as of the creations of synthetic chemistry. All the men, without one solitary exception, who have commanded Nature in the past—the man who made the wheel; the man who built the Forth Bridge; the creator of the steam engine; Pasteur, the conqueror of disease; Galileo, the inventor of the telescope; or Perkin, the creator of the coal-tar dyes—have commanded Nature by obeying her. Only in virtue of their obedience are they creators. The countless men who have failed and are forgotten, or are remembered with scorn or pity, alike in science and in art, are those who either were unconscious of the existence of Nature's laws, and so fought against them unknowingly, or those who thought that they themselves were superior to the mighty universe of which they formed a part, and so fell; for Nature never forgives and never forgets. She accepts no excuses, she makes no exceptions, and the mother of all wits has never yet been outwitted.

Chemistry and the Imitation of Nature. And now let us consider the second of the great directions in which synthetic chemistry is advancing. The writer is endeavouring to invent easily memorable names which will aid the reader, and perhaps the term *imitative chemistry* will form a useful contrast to *creative chemistry*. The very best that the most brilliant chemist can accomplish is very little compared with the achievements of the living cell, which is the supreme chemist. An insignificant red cell, one of five millions that are to be found in two pins' heads space of the blood of Professor Berthelot, or Professor Fischer, is capable of making the compound hæmoglobin which those two great creators, aided by all the other chemists in the world, could not begin to imitate. Nevertheless, the chemical synthesis of vital products is making rapid advance, as we have already seen, and it is by no means inconceivable that even hæmoglobin, which is believed to be the most complex chemical substance known, and to contain more than a thousand atoms in its molecule, may some day be manufactured on the laboratory table at perhaps a thousand times the difficulty and expense with which it is manufactured in the blood of the boy who dusts that table in the morning.

The Limit to Imitative Chemistry. As in the last case, any detailed discussion of the accomplishments of this imitative chemistry is out of the question. There is no need to refer the reader again to Professor Meldola's recent book on this subject, but we must ask him to turn back to the quotations from that book which have already been made and to our comments thereon.

For it has clearly to be recognised that imitative chemistry, as at present practised, is imitative only in so far as the results are concerned. The chemist can imitate alcohol and various carbohydrates, for instance, and his *products* are identical in many cases with those of the plant. But the chemist does not imitate the *processes* of the plant. His methods are the same as those employed in "creative chemistry." Now the many successes of imitative chemistry must not blind us to the fact that, despite them, this imitative chemistry is not the real thing. While Nature's results are obtained, her processes are ignored. Hence we may be certain that there must be a limit to the artificial synthesis of the vital products, and that limit may soon be reached.

Chemistry Must go "Back to Nature." Chemists may find that they can go a long way in the manufacture of a large number of compounds which are produced by living cells for their own purposes. But it is very likely that the imitation of the most essential compounds found in living matter, the compounds which most truly express and perhaps condition its life, may be found impossible so long as chemists continue to employ processes which are not, of course, properly speaking, *unnatural*, since the laws of chemistry are always observed in making them, but which, at any rate, are not the processes which Nature chooses to employ.

It seems probable, then, that if this branch of chemistry is to achieve its utmost it must go "back to Nature," and attempt to imitate the processes which she prefers, though they are evidently not the only processes she permits, for the making of these compounds. It might then be found—in fact, nothing else could be found—that the adoption of the processes employed by the living cell would enable imitative chemistry to do all that the living cell can do. But there is a great difficulty in our way.

What we are asking chemists to do is to imitate the unknown. No chemist in his senses would dream of employing high temperatures and powerful reagents for the manufacture of these compounds if he were able to employ the cell's own processes. He uses his own methods merely because he cannot imitate methods which he does not understand. Indeed, the supreme problem of chemistry at this hour is the understanding of the chemistry of life, and to this topic we must soon turn.

Can We Make Radium? But before we pass to this difficult and fascinating subject, allusion must be made to a new kind of synthetic chemistry, of which chemists are beginning, just in these last few months, to perceive the possibility. It need hardly be said that it is radium which has opened out this new prospect.

The synthetic chemistry of which we have been speaking is the synthesis of compounds, and, of course, anything which is the product of synthesis, or putting together, must necessarily be a compound. Only a few years ago, to speak of the synthesis of the elements would have been considered as foolish and meaningless as to speak of their analysis. The essential idea of an element was of a something which could neither be put together nor taken to pieces. But we now believe that the atom of any element is not really atomic or indivisible. It has been conclusively demonstrated that the atom of

radium, for instance, is capable of analysing itself, so to speak, into smaller parts, among which in all probability five atoms of helium may be numbered. It seems to be impossible to control the analysis of the elements, but it is certainly possible to observe it.

Now, this necessarily suggests to the mind the possibility of the converse process. If radium be capable of analysis, may it not be possible to build it up by synthesis of its parts? This conceivable synthesis of the heavier elements is the new possibility which, like its predecessors, is certainly worthy of the name synthetic chemistry—far more worthy, indeed.

The Genesis of Radium. These words are fortunately written just late enough for reference to an extremely important controversy on this point, which was started by Lord Kelvin in a letter sent to the "Times" in August, 1906, and which called forth the most recent views of such distinguished workers in radio-activity as Sir Oliver Lodge, Mr. Frederick Soddy, and the Hon. R. J. Strutt. If the reader will recall what was said when we were discussing radium, or will turn back to those sections of our course, he will be able rightly to value the remarkable suggestion made by Lord Kelvin in his third and last letter.

Lord Kelvin accepts the statement that the life of the radium atom is finite (perhaps 1,800 years, which is Professor Rutherford's latest estimate), and yet he is inclined to question the belief of workers at the subject, that radium is an evolutionary product of uranium. Mr. Strutt, therefore, asked him what theory he held as to the origin of the radium now existing on the earth. No one would suggest that this radium was made by "special creation" 1,800 years ago, and if it is not derived from the uranium, with which it is always associated, whence comes it? In reply to this, Lord Kelvin suggests that the radium atom may be formed by a "concourse of atoms" crushed together, so to speak, in the course of the condensation of the nebula from which the solar system and all the parts thereof are formed.

Did the World Begin as One Huge Atom? In other words, Lord Kelvin suggests that the large compound atoms, as we know them, may have been formed by a process of natural synthesis, and this is a suggestion worthy of the most careful thought. The reader will remember that hitherto opinion has been inclined—accepting the view that large atoms, such as those of uranium and radium, break down into smaller ones—to suppose, as Professor J. J. Thomson puts it, that the known universe must have begun as one huge atom, of which all contemporary atoms are disintegrated parts.

The idea suggested by Lord Kelvin is that the process of atomic evolution has two phases, and may be, indeed, a balanced process. Without making any assertions as to Lord Kelvin's beliefs (which, it must be confessed, are somewhat difficult to define), we may, at any rate, realise the possibility that atomic synthesis as well as atomic analysis—building up as well as breaking down—is occurring at the present time. The idea that the whole history of the universe is a continuous process of the analysis and disintegration of one mighty atom is beset with a thousand difficulties, and yet we have seen that it has been suggested as the apparent inference from the facts of the natural analysis or breaking down of large atoms, which have lately been discovered.

Breaking Down and Building Up Atoms. It seems to the present writer that these difficulties disappear if we conceive that both processes may be in operation according to the conditions. On the one hand, there may be breaking down of large atoms into more numerous and smaller ones; but, on the other hand, there may be a reciprocal process of natural synthesis, or "concourse of atoms," to use Lord Kelvin's phrase, whereby numerous small atoms are merged into one another so as to form larger and more complex ones, such as the atom of radium. Indeed, to the present writer it seems that there is no warrant for the assumption that the atom of radium must either be formed by analysis of the larger atom of uranium, or else must have been formed by synthesis of, probably, one atom of lead and five atoms of helium. Lord Kelvin stated: "Radium (atomic weight, 225) may be a compound of five atoms of helium (atomic weight, 4×5) and one atom of lead (atomic weight, 205)." Why should we be asked to take one of these views as true and reject the other as false? There is nothing contrary to what is known in the belief that both views may be true. In the case of such a compound as carbonic acid we know perfectly well that it may be formed, on the one hand, by the decomposition or analysis of a carbonate, or, on the other hand, by synthesis of carbon and oxygen directly. Similarly, there is no reason why, under appropriate conditions, that complex compound which we call the atom of radium should not be formed by analysis of the still more complex compound called the atom of uranium; or why, under other conditions, it should not be formed by concourse or combination of atoms of lead and helium—which may, perhaps, be a synthesis as natural as the synthesis of oxygen and carbon to form carbonic acid.

An Artificial Concourse of Atoms. Though Lord Kelvin would seem to be the first to have suggested the natural synthesis of the elements, a year or two has now passed since Sir William Ramsay recognised the possibility of the artificial synthesis of heavier atoms by means of lighter ones. We already know that the transmutation of the elements under certain conditions is a fact, but the only transmutations we know are those of larger atoms into smaller ones, incredible quantities of energy being meanwhile evolved. We know no instance as yet of the new synthetic chemistry which would consist of the making of large atoms from small ones. There is a fundamental distinction between the two processes. In the former, energy is evolved; in the latter, which as yet we can only imagine, energy—and in enormous quantities—would have to be supplied.

Now, it looks as if the supplying of energy for the purpose of this "concourse of atoms," or

atomic synthesis, whether natural, as Lord Kelvin supposes, or artificial, as Sir William Ramsay expects to achieve, must involve an infraction of that law of the *dissipation of energy* and its loss of availability, which Lord Kelvin himself first discovered, and which has been discussed in the course on Physics.

We cannot here expect, however, to anticipate all the discoveries and solutions of the future, and so we must now leave imperfect—like all other human knowledge—the study of synthetic chemistry in its various forms.

The Chemistry of Living Things. Two great subjects remain for brief treatment ere we conclude this course. Of these, the first is the chemistry of life and living processes. Incidental reference has often been made to vital chemistry in preceding pages, but here it will be well to state the main facts in a systematic way, and, first of all, as to what constitutes the peculiar character of vital chemistry.

The first proposition which must here be repeated is that all the known laws of general chemistry are strictly and rigidly observed by living matter. No form of living matter that we know is capable of annihilating or creating an atom out of nothing, or of destroying or creating energy. The law of the conservation of matter, with the reservation involved by the study of radio-activity—is observed in the chemical processes of living creatures, and so also is the law of the conservation of energy. Secondly, no element is found in living matter that is not found elsewhere. Thirdly, the elements found in living matter are in every respect identical with other specimens of the same elements occurring elsewhere. Fourthly, no processes are known to occur in living matter that cannot be imitated more or less successfully outside it. This is true even of the remarkable process called fermentation, which is very extensively employed by living matter for its own purposes.

Having insisted on the ultimate identity of the laws that govern all chemistry, including the chemistry of life, let us now state the general facts which the world of life displays to the chemist.

The Wonderful Cycle of Life. For a very long time the vegetable and animal kingdoms have been regarded as forming the two divergent limbs of the great V of life—both kingdoms having their origin, it was supposed, in some primitive organisms that were neither animal nor vegetable. This conception, however, which involves much confusion from the chemical point of view, must be modified not only for that reason but for other positive and final reasons which it is not our business to discuss in this course. On the contrary, we may be assured that the first living things were essentially vegetable and that the animal world is an offshoot from the vegetable world. If we clearly retain this idea, we shall be ready to understand the next paragraph.

In considering the chemistry of living things we must plainly begin with the plant, which is not only the ancestor of the animal, but is also the necessary source of its food; for, even if we are not vegetarians, what is the ox but transformed grass?

Let us consider, then, the typical plant. It displays in its vital functions that transformation of energy with which the student of physics is always familiar; but we have already stated that the plant, though a living thing, offers no exception to the law of the conservation of energy. Whence, then, is the energy which the plant transforms?

Transformed Sunlight. The sun is the source of the energies displayed by all living things, whether animal or vegetable. The motion of the eyelid which intermittently cleanses your eye-ball with a tear as you read is transformed sunlight. Now, let us see how this works out.

The energy which constitutes sunlight—including many rays which are invisible to our eyes—is focussed, so to speak, by the chlorophyll of the plant leaf. In virtue of this influx of energy, the living protoplasm of the cells of the leaf is enabled to effect that extraordinary dissociation of carbonic acid which we have already discussed. On the other hand, the plant elsewhere obtains water and inorganic salts, which include among their constituent elements nitrogen, sulphur, and phosphorus. The upshot of the plant's activities is the formation from these food materials—on which *we* should so soon starve—of the countless complex organic compounds, a few of which we have already discussed. In them the kinetic energy of the solar radiation is still conserved in the form of what we call potential chemical energy. The plant does not create energy, but it is an incomparable collector of it.

The Energy of the Plant. On the other hand, the plant, like every living thing, is also a dissipator of energy. Living protoplasm, whether found in the plant or in the animal, must breathe—must take in oxygen and give out carbonic acid and water. But the breathing of a plant, though necessary to its life, is a very much less rapid process than the breathing of an animal. The plant has not much occasion for the using up of energy. One great distinction between the plant and the animal is that the food of the former comes to it while the latter has to find its food. Thus, the plant is not under the necessity of using up much energy for purposes of locomotion, whereas the animal, which has muscles and uses them, must breathe extensively in order to obtain the oxygen which burns up its food within its body with the transformation of potential energy into kinetic energy.

Therefore, though we must never forget that a plant breathes and must breathe, we look upon the plant as, on the whole, a synthetic chemist—a converter or transformer of kinetic into potential energy.

The Ancestor of Us All. The sun shines upon animals as well as plants, but animals have no apparatus whereby they can transform the kinetic energy of sunlight into, for instance, the kinetic energy of muscular motion. The carbonic acid of the atmosphere

and the nitrates and phosphates in the soil furnish no diet for the animal. *The animal world is absolutely dependent for its existence upon the vegetable world, not only because the vegetable world is its ancestor but because the vegetable world is its daily bread.* Now, just as the plant is typically a *synthetic* chemist so the animal is typically an *analytic* chemist, breaking down that which the plant built up. The potential chemical energy thus obtained, which, be it remembered, is transformed sunlight, is converted by the animal into kinetic energy which, in some cases (as, for instance, the light of the glow-worm) may be absolutely identical with part of the light which it originally was. But muscular motion is the most common form which this energy assumes. Lastly, the animal dies and returns to the dust. There its body is resolved by microbes or bacteria—the indispensable part played by which in the existence of man himself upon the earth must be discussed in the course on Bacteriology—into simple sulphates, phosphates, and nitrates which we call manure, in which form they are again taken up by the plant. So said Tennyson:

> "And from his ashes may be made
> The violet of his native land."

Perhaps the writer may be allowed to quote his own previous expression of the significance of this: "As we dwell, we living things, in this our 'Isle of terror,' each of us is inalienably bound to all the rest. So you may be selfish for a century, but at the last others will claim your dust. For altruism is the law of Nature."

The Chemistry of Food: A Life for a Life. Many a large volume might be written upon the chemistry of diet; here we are merely concerned with the principles, and must endeavour to reduce the multifarious diet of the many kinds of animals that inhabit earth and sky and sea to their simplest terms.

Every animal (as, for instance, a man or a sea-anemone) must have a supply of water and a supply of certain inorganic salts. In so far as these two items are concerned the needs of the whole living world are identical, for plants also must have water and salts. But if the plant has water, salts, and the ordinary gases of the air, it has enough or a feast. On the other hand, the animal, and this is true of all animals, must have some kind of proteid and, in the last resort, this proteid is invariably a vegetable product. The plant made it out of its raw materials—having easily solved the problem at which synthetic chemistry is still heavily labouring—and the animal uses it. For our present point of view it matters not a straw whether the animal be a cannibal who obtains his albumin by eating the muscles of a fellow man, or be a cow munching grasses. In the last resort, the vegetable world is the source of all proteids for all animals, and we are not here concerned with the appalling moral questions which arise in relation to Nature's apparent law, *a life for a life.*

Animal life can be sustained on water, salts, and proteids. If the diet contain these three constituents alone the animal body will yet be found to contain *fats*, and *carbohydrates* such as sugar. Now, we know for certain that the animal is incapable of synthesising fats or sugars from their elements or from simpler compounds, and we have clear evidence that when proteids, salts, and water constitute the whole diet, the proteids supply the source of the carbohydrates and fats which the animal body displays and utilises. This one fact will give us some little idea of the almost incalculable complexity of the proteids, and the appalling nature of the task which the synthetic chemist essays when he attempts to synthesise an artificial proteid.

The Three Essentials to Life. But in actual practice it is found that the animal, including man, takes carbohydrates and fats *as such* in its diet, and so we have five distinct items constituting the food of a man: proteids, fats, carbohydrates, salts, and water. In certain cases the second may be dispensed with; in certain cases the third; life may continue if both second and third be omitted; but if either the first, fourth or fifth be withheld death necessarily follows.

The vegetable body requires food, partly for the accumulation of tissue and partly as a source of energy; but we have seen that the vegetable body spends scarcely any energy. The animal body also requires food for two purposes, and two alone—the making of tissue and the supply of energy. The water and the salts are necessary for life for a number of reasons, though they cannot clearly and definitely be included under either of these purposes. The animal's expenditure of energy is extremely high, and by far the greater part of its food is required for this purpose. The fats and carbohydrates are the principal sources of the potential chemical energy, most of which the animal will convert into motion. These failing, the proteids will be used, but when a suitable diet is employed the proteids are very little used for this purpose, their main concern being to replace waste of tissue. Proteids, indeed, are the chief constituent of all protoplasm. Vegetable protoplasm makes them and animal protoplasm snatches them, ready made, from the vegetable.

Proteins—the Principal Food Substances. We are using the term most commonly employed in this country for those extraordinarily complex compounds which, in certain varieties, are the chief constituents of all living things. At an important scientific meeting in Canada, in the autumn of 1906, some steps were taken, however, to obtain a greater uniformity in the nomenclature. At present, the words *proteid*, *albumin*, and *albuminoid*, are frequently used interchangeably, but the splendid work of Emil Fischer has necessitated a more precise nomenclature. It is therefore desired by those in authority that the term *protein* should be employed as the general name for all those substances. It is at present so used in America and to some extent in Germany. These proteins, then, as they will be commonly called before

long, may be divided, largely in consequence of Fischer's work, into about seven groups, or sub-classes. It is possible to make artificially certain substances which belong, or all but belong, to the simplest of these sub-classes—the group known as the *protamines*. From these, which are relatively simple, we pass in increasing complexity through a special *albumin*, such as egg albumin, through such a substance as gelatin, which is rather more complex still, on to the *gluco-proteins*, such as mucin, the characteristic constituent of the stuff called *mucus*, which is produced by mucous membranes, on to the *nucleo-proteins*, and at last to the coloured or *chromo-proteins*, the most celebrated and complicated of which is hæmoglobin, the red colouring matter of the blood.

The Most Familiar Proteins. Of course, it will be some time yet before the term proteid is discarded. It is the generally recognised word in this country, and we have employed it everywhere except in the last paragraph. But we desire that the reader should not be confounded when he meets the word protein, as he certainly will do more frequently every succeeding year.

We may quote from Sir William Ramsay a very brief description of the most familiar sub-class of the proteins. It contains the main facts in very small space.

"Albumins are the chief constituents of animal organisms. They are soluble in water, but are precipitated by warming their solution, or by the addition of strong acids—copper sulphate, mercuric chloride, basic lead acetate, etc., and also by tannic acid or alcohol. They turn yellow when boiled with nitric acid; give a red colour with Millon's reagent (a solution of mercuric nitrate containing N_2O_3); and violet with caustic soda and a trace of copper sulphate. They combine with both acids and alkalies. They contain sulphur. When hydrolysed by boiling with baryta-water, the chief products are amido-acids, such as amidoacetic acid (glycocoll), amidocaproic acid (leucin), etc. They are converted by gastric juice (pepsin) into a soluble grey mass, named peptones, which are not coagulated on boiling."

Chemical Processes in Living Matter. Utilising the Greek word *Bios*, life, chemists now frequently speak of bio-chemistry in order to indicate the study of the chemical processes that occur in living matter. This term has the advantage that it is almost identical in all languages—an advantage common to words of Greek origin and largely explanatory of their wide use—and it has the further advantage that it avoids the term *vital*; which is apt to suggest the theory of Vitalism, unless that theory has been explicitly discussed and abandoned, as in our case.

The study of the proteins is the cardinal necessity for the bio-chemist, and in our brief discussion of the subject we shall utilise the volume just published by Mr. John Murray, under the title "Chemistry of the Albumins," by Dr. S. B. Schryver. This volume consists of lectures delivered before the University of London, and is one of the quite invaluable series of such volumes which have been issued under the auspices of that great institution since it became a teaching reality and not a mere examining body. It is necessary to add that Dr. Schryver uses the older terminology, and that what he calls albumins, for convenience, are now to be known as proteins.

We cannot here discuss the modern theories as to the constitution of the various albumins, the possibility of the crystallisation of some of them, as, for instance, hæmoglobin, or the extremely important question of the various degradation products of the albumins, recently studied with splendid results by Fischer and his pupils. Briefly, we merely note that among these degradation products are included fats and carbohydrates. These are demonstrated chemical observations, and are in strict correspondence with what was said above when we were discussing the dietary groups. Also, we can only refer the reader to these extremely valuable lectures for a discussion of the chemistry of hæmoglobin, with the importance of which the reader is already acquainted.

Three Fundamental Facts. Here, however, we must attend carefully to the theories of bio-chemical action, which the author discusses in his concluding lectures, and which are of transcendent interest on every ground. And first, as to definite facts. There are three which are obvious and fundamental:

1. *That the organism is in a state of constant change.* "To live is to change," says Cardinal Newman, somewhere; and this is true not only of the psychical life, but also of the physical. Ceaseless change in the molecules of living protein is a necessary condition of life wherever it is manifested.

2. *The molecule of the albumin*, which performs the normal chemical function necessary for the maintenance of life, compared with ordinary molecules, *is of enormous size and very unstable;* it loses many of its properties on the application of a very moderate amount of heat.

3. *The chemical reactions necessary for the maintenance of life take place within very narrow limits of temperature.* Furthermore, these temperatures are very much lower than those which are otherwise found necessary. For instance, a commonplace in bio-chemistry is the oxidation of fats and carbohydrates by means of the oxygen of the air at the temperature of the body. "Hence," says Dr. Schryver, "we are dealing with abnormally large molecules which are constantly bringing about chemical change at a temperature of about 37° C., which changes occur *in vitro* (that is, in a test-tube) only at higher temperatures, and with the use of energetic chemical reagents which do not exist in the body. We are forced, therefore, to seek for some special explanation of bio-chemical reaction."

Life "A Series of Fermentations." Now, it appears that the explanation of the possibility of these reactions under these conditions must ultimately be expressed in terms of what we know as *fermentation*—in short, putting the matter unphilosophically, crudely but memorably, "life *is a series of fermentations.*"

The technical term employed is *catalysis* or *catalytic action*. This term is rather wider than the term fermentation, but all fermentation comes under its heading.

A ferment is a substance which induces chemical change by its presence, without itself undergoing any change. The most familiar instance is the pepsin which Sir William Ramsay mentions in the quotation above. More powerful than the pepsin of the stomach is the trypsin which is produced by the pancreas or sweet-bread. These substances, without themselves undergoing any change, are capable of breaking down the ordinary albumins of the food in such a fashion that they are afterwards capable of absorption into the blood.

Ferment Action. A ferment, or *enzyme*, as it is often called, is a product of the living cell, and is highly complex in composition, but it is possible to find outside the living body parallels to the action of a ferment. For instance, we know that the peroxide of hydrogen, in the presence of platinum black, is decomposed with the evolution of free oxygen, while the platinum remains unchanged at the end of the reaction. Various theories of ferment action have been advanced, but it suffices for us to note here that the reactions due to ferments in the body are rarely, if ever, much more complicated than this catalytic decomposition of peroxide of hydrogen; indeed, we may say that oxidation, reduction, hydrolysis, and dehydration will include all, or practically all, the forms of ferment action. Furthermore, the chemical changes induced by ferments are usually such as would be apt to occur in any case though not at such a speed. This will explain the important definition of Professor Ostwald, who is one of the greatest living students of the subject: "a catalysor is a body which, without appearing as an end-product in a chemical reaction, alters its velocity."

Theories of Bio-chemical Action. The oldest theory of bio-chemical action contains as its essential part the proposition that the living molecule (as, for instance, in the contractile cell of a muscle) is capable of taking up oxygen into itself, which is thereby held at the disposal of the organism for the purpose of oxidation. The reader is familiar with this theory.

We have referred to the next theory, that of Pflüger, which assumes the truth of the theory of intra-molecular oxygen, and the special character of which is its insistence upon the potential energy in the cyanogen group assumed to occur in the living albuminous molecule. Many subsequent observers have restated this theory in various forms.

Later, we have the remarkable theory of Ehrlich, who conceives of the whole protein molecule as having a ferment-like action, part of it being specialised for the purpose of anchoring oxygen to the molecule, and another part being specialised for the purpose of anchoring various oxidisable substances, with obvious consequences. To Ehrlich we owe the idea of specialisation of function within the molecule. This is a very great advance. The theory is often known as the *side-chain theory*.

Then, only three years ago, Professor Verworn combined the side-chain theory of Ehrlich with the theory which assumes the existence of substances which can act as oxygen carriers, and with the theory of intra-molecular oxygen. This, which is known as the *biogen* theory, will undoubtedly require much modification, but at the present time it may be regarded as the best working hypothesis available.

The Chemistry of the Stars. Space does not here avail of the discussion of what is usually known as *physiological chemistry*, which discusses the particular chemistry of the various organs and tissues of the body; we have preferred to discuss the more fundamental subject of bio-chemistry in general.

And now we must turn from the chemical discussion of life upon our little earth to a study of the chemistry of the illimitable heavens. This is a subject for volumes, and here we must merely state the main outstanding facts. Elsewhere in this course, and in the course on Physics, the reader has made acquaintance with the method by which many facts of the chemistry of sun, stars, comets, and nebulæ are as positively known as if portions of those heavenly bodies had been sent by celestial post to the chemist's laboratory. We know that there is no more certain evidence of the identity of the atoms of any substance than the characters of the light which those atoms give out when the substance becomes luminous. Thus, by means of the spectroscope and spectrum analysis, we have acquired knowledge which some of the wisest thinkers of not so long ago declared to be forever beyond the reach of the human mind.

Is Evolution Universal? The first amazing, yet utterly natural, fact is that the elements of which our own bodies and our surroundings are composed also constitute the heavenly bodies. In the light of the most recent knowledge it is, perhaps, not possible to say without some qualification that we know of no elements in the heavens that are not found on the earth. We may undoubtedly believe that there is no kind of celestial stuff which is utterly distinct from terrestrial stuff; but it is quite possible that there may be represented in the heavens, stages or forms of atomic evolution with which we do not happen to be familiar in this our little moment of time, and upon this our "lukewarm bullet," as Stevenson called it. In Sir Norman Lockyer's opinion there is, for instance, an element characteristic of the corona of the sun, and this element is known as *coronium*. But though this were so—and a thousand instances beside it—the fact would remain that there is a real identity of composition alike in heavens and earth. We may also remind ourselves of the celebrated case of helium, discovered about a quarter of a century ago in the sun, and named accordingly, but now known to occur upon the earth also.

The study of inorganic evolution in its widest sense includes the study of the evolution of atoms and the evolution of planets, suns, and stars. But we must not confine ourselves merely to atomic evolution as it has lately been recognised

in the laboratories of earth. It is surely extremely probable that atomic evolution also occurs in the heavens. Our minds having been prepared by recent knowledge, we should think it very strange indeed if no case of atomic dissociation could be recognised in the sun.

Evolution in the Heavens. Now, Sir Norman Lockyer has devoted a great part of his life to the study of this subject. He has shown, what is now a commonplace, that the spectrum of an element alters with alterations of temperature; and no modern student of radium and its revelations can doubt that these changes are due to atomic changes within the luminous substance that is examined, and, in the upshot, that these atomic changes are due to atomic dissociation. Thus, in the case of iron, which is known to occur in the sun, there is reason to believe that such atomic dissociation occurs. Says Professor Duncan: "In one part of the sun, called the 'reversing layer,' the spectrum of iron is represented by nearly a thousand lines. In another part of the sun, called the 'chromosphere,' which is apparently at a much higher temperature, the spectrum of iron is reduced to two lines only. It is difficult to see what other explanation we can assign to this remarkable fact than that at the higher temperature of the chromosphere the atom of iron is decomposed or dissociated into some simpler constituent which appears at that point. This explanation is rendered additionally valid by the further fact that in sun-spots one set of iron lines is found, and in the chromosphere, quite another." These and other reasons lead us to suppose that in the sun, as Lockyer says, "we are not dealing with iron itself, but with primitive forms of matter contained in iron which are capable of withstanding the high temperature of the sun after the iron, observed as such, has broken up." Similar evidence can be adduced to show that other elements, such as magnesium and calcium, are also dissociated in parts of the sun.

A Constituent of the Hottest Stars. The stars also yield evidence of the same thing, not only in the case of these metals, but also in the case of many others, such as copper, chromium, and strontium. The term *proto* has been applied (until further knowledge) to the names of the dissociated constituents of the element as they are found in the sun and stars. Says Professor Duncan: "A very important proto-element is proto-hydrogen, discovered by Professor Pickering of Harvard University," in a certain star. "The spectral lines representing this substance Pickering at first supposed to signify a new element; but he was able to show later that they belonged to a new series of hydrogen lines constituting a form of hydrogen unknown on earth." This proto-hydrogen has since been discovered in other stars, and it is extremely noteworthy that the stars in which it occurs are the hottest stars known.

The Temperature of the Stars. Now, this last fact leads us to a brief discussion of the great theory of Lockyer, that atomic evolution in the heavens is an orderly and continuous process, dependent upon orderly and continuous changes of temperature in the stars. The study of the light given out by various stars seems to show quite clearly that they vary in temperature, and Sir Norman Lockyer has divided the stars into three groups: *gaseous stars*, *metallic stars*, and *carbon stars*, the first group being of the highest temperature and the last group of the lowest. We may say, in a word, that the evidence of comparative temperature depends, as in the case of a heated poker, upon the comparative lengths of the spectra given out by the stars.

Examining the stars in this fashion, Sir Norman Lockyer finds that the chemical composition of a star varies with its temperature. The hottest gaseous stars seem to consist of comparatively few gaseous elements; then it would appear that as the star cools there occurs some such "concourse of atoms" as Lord Kelvin has lately been writing of.

Fascinating though it be, chemistry is not the only subject needed to make an educated man, and we must bring our present study of it to a close. We have merely opened the door to endless wonders, and have peeped in for but a moment.

The Future of Chemistry. In arranging the proportions of our vast subject we have deliberately recognised the all but overwhelming importance of recent work in chemistry. We have not at all followed the orthodox lines of an elementary chemical textbook; but the truth is that those orthodox lines will very soon cease to be orthodox, and that a vast proportion of the reactions and technical processes, descriptions of salts, and so forth, which now occupy so much of the chemical textbooks, will be regarded as no more worthy of a place in a discussion on chemistry in general than, let us say, the minute details which distinguish the muscular anatomy of the tail of one kind of fish from that of another kind of fish will be deemed worthy of a place in a general textbook on biology. Though principles depend upon details, and though one little fact is quite sufficient to overthrow the greatest of generalisations, yet we must recognise that for the purposes of education the details are but means to an end, and that that end is the *knowledge of principles*.

The writer takes leave of his readers with the utmost regret and with the earnest hope that here and there he may have imparted to them some of the interest which his fresh review of the subject as a whole has excited in him. He can scarcely think that anyone has enjoyed reading this course as much as he has enjoyed writing it, but at least he hopes that the pleasure has not been all on one side. And we may hope, also, to meet again!

Chemistry concluded; followed by

APPLIED CHEMISTRY

For the Best Books on Chemistry the student should see the discussion at the end of PHYSICS.

THE SHOEMAKER AT HIS LAST

Top Boots. Shaping the Last Lasting, Welting, Sewing and Stitching. Trimming. Shaping. Soling. Shaping and Paring. Finishing

By W. S. MURPHY

Top Boots. When it ceased to be the ambition of every respectable young man to possess a pair of fine top boots the bootmaking trade declined in its most artistic and profitable branch. A top boot is a big job, and calls for patient care, deft hands, and a good eye for effect. We do not refer to the coarse things that are made for ostlers and stable-boys, but to the boots of gentlemen. This trade is still the mainstay of many hand-working shoemakers. Riding, cavalry, and livery boots have all special models, and the civilian top boot differs from them all. What distinguishes tops from every other form of boot is the long leg and the plain front. Horsemen's boots of the lower class are simply plain-fronted boots with leather stovepipes stuck on to them. But the best class tops are one piece of fine leather from head to toe, with side-seams joining backs and fronts, lined with fine chamois or morocco, and topped with a broad band of soft leather.

Making the Top Boot Upper. When measuring for top boots, the length and thickness of the leg must be taken as well as the proportion of the ankle. Every fraction of an inch in the limb has its graduation to be accounted for, if the boot is to fit properly. Cutting tops is anxious work, and can be safely undertaken only by skilled workmen. The best way of acquiring the requisite skill is study of good models and instructions from a practical man while he is at the work. Having got all your stuff gathered for the tops, the next business is to sew and shape it. The long side-seams, the stiffening of the backs, the shaping of the fronts, the fine adjustment of the linings, take much patience and skill. Then every seam must be flattened out to almost invisibility. But when all is done, the result is worth the pains; you have a splendid boot, fit to be worn by a king —that is, always provided that the soles and heels are worthy of the tops.

No matter how well it has been sewn, the boot-top is rather an unshapely thing; but we have the remedy. Made of hard wood, and fashioned to the shape of the human foot, the last is the mould of the boot. The best kind of last [33] is in two parts, the lower half representing the body of the foot from the middle of the ankle, the upper part giving the front of the leg and the instep. Over this block the top is stretched and shaped.

Stock of Lasts. Lasts are cheap, and it pays to keep a large stock of them. In addition to a pair of lasts for every size, it is good policy to keep special lasts for particular customers. A first-class shoemaker generally has a large number of lasts rented or owned by customers, for whom they have been specially prepared and kept.

Shaping the Last. With the measure and notes in hand, we go to the last rack and take down the lasts required. If no size corresponds exactly with the measures, we take the nearest in size, and begin to work. For lengthening, put a neatly pared piece of leather on the heel, like a pad; lay a toe-cap on the toe. For a higher instep, cut a neat long patch and put it on the instep, and so on for all other peculiarities. The pieces must be finely graded or skived, so as to fall in with the general outline of the last, and pasted firmly on. The ideal last is flat on the heel and under the toe-joints, and finely tapered on the top of the toes.

Cutting Out. If a shape be not already in existence for this last, we have to cut one exactly the size and shape of the sole as a guide for finding the size of the insole. With this and our measures we go into the leather store. Insoles should be of good body, but thinner than soles, the leather from the shoulder of an average hide suiting well. Cut out to shape from the hide, reserving scraps for packing. From the same hide cut the stiffeners.

Sole Cutting. Next lay the hide of sole-leather on the cutting table and cut off right and left soles, rough to measure. This leather should be stout, firm, yet flexible, of a brownish buff colour shading to dull white. Last are the welts. Some bootmakers buy these ready-made, of an oil tannage; but they may be cut from a well-tanned English shoulder that has been shaved evenly. Cut strips over ¾ in. broad, the cross-way of the hide. Gather the stuff together, and fling it all into a tub of water, sousing well over. When all have been thoroughly soaked, take out everything but the welts, and lay out in an open place to dry free from water.

Blocking the Insole. While still damp, the insoles are scraped and lightly beaten smooth with the broad hammer, stretched on the lasts, tacked down, and left to dry in shape. As soon as they are firm, the insoles are cut neatly to the edge of the last, the sole lined across into three parts - the heel, the waist, and the fore part—and skived away finely at the waist. Keep the curve well within the sides of last, cutting deeper to the inside of the foot. The insole has to be sewn to the upper, and the operation is a delicate one. To make it as easy as possible, we hole the insole by itself. Round the edge of the insole make a bevel, or feather, about ½ in. broad, cut sharply half through the leather at the inside, and tapering to the edge, forming a corner all round the sides of the insole.

Take the awl and strike holes from the face of the insole to the surface created by the feathering. It is plain that if a thread is passed through those holes, a strong catch will be formed.

Lasting. Lace the top neatly with a strong leather lace up to the bend of the foot. Sit down on the bench, put the last between your knees, heel to the left, place the top evenly on the last, and pull it strongly down, drawing more to the toe than the heel. This done, turn the last sole upwards, and take the heel between your knees; pull the toe of the upper over the toe of the last and tack it into place. Watch carefully that the top is centred on the last, and then begin tacking all round. For pulling down the top we are provided with a pair of fine strong pincers. Begin round the toe and work evenly along both sides to the heel. Before fixing up the sides, however, we put the side linings in between the linings of the tops. When the top

33. KNIFING A LAST

is being folded down on the last, wrinkles and pipings naturally form; these must be beaten out and tightened over, or unsightly work will be the result. Sometimes the last is hard to drive into the top, and we have many recipes for overcoming the difficulty easily; but we know of none like intelligent ingenuity and patience. The top has to be made smooth over the last, and the job can be done.

Welting. From lying in the tub all this time, the welts are soaked with water; strike the surplus liquid out by rubbing down with a hammer handle, or anything handy; then skive the inner edges on the grain side. Take the one you are going to work with, and fit it round the sole of the last, marking where the creases caused by the turnings are highest. Cut the creases out, taking care not to lessen the strength of the welt. A welt properly shaped lies as flat and keen as a knife blade. The welt should come up the sole to about the end of the waist, and no further. If too long, cut off the ends.

Sewing and Stitching. Our work up to this point has been preliminary; the serious and important business begins now. Have ready several threads, seven-ply, well waxed, and with strong bristles on the ends; put on the sewing-mittens—skeleton gloves that leave the fingers and thumb bare, and protect the palm and back of the hand; set the boot between the knees, heel outward, and bring the belt over the waist of the boot, tightening it with your left foot on the buckle. Start sewing on the side nearest the left hand; drive the long point of the awl through the hole in the insole, through the welt, and bring it out through the top or upper, and up through the welt. Send one end of the thread the same path, and draw till half is on one side and half on the other. Pierce with the awl again; put the bristle in the right hand through from above, and the bristle in the left hand through from below; grip the bristle coming up with the right hand, and the other going down with the left; draw firmly yet gently, winding the cords round your hands to get purchase, and then tug once, twice, thrice, with a swimming action, to drag the threads through [**34**], and give a last firm tug to tighten the stitch. For this operation strength and intelligence are required in equal proportions. Mere force will break the insole or tear open the path of the thread. After careful practice, the art comes naturally, and the skilled bootmaker mechanically forms the stitches firmly and accurately. In this way the whole welt is sewn, and the insole, top and welt, all firmly joined together.

Sewing Round the Heel. On the heel we have no welt, and the top must be joined in some way to the insole. Nothing could be simpler. Take a new thread, send the awl curving as before through insole and top, sew strongly round, and secure by a knot at the end.

Trimming. As stitch after stitch was made, the tacks holding the top to the last were taken out; but there are yet other trimmings to be done. Rough edges come up from the upper, and the welt protrudes over the waist. For hunting and other classes of heavy boots, the welts are left on; but in ordinary boots the welts are reduced at the waist. All the superfluous stuff on top and welt has to be finely pared off, but not so closely as to weaken the stitching. When this has been done, the seams should be hammered down smooth with the flat head of the broad hammer, care being taken to avoid bruising the stitches.

Soling. Between the surface of the insole and the level of the welt there is a difference which must be filled up. A padding of felt is favoured by many shoemakers, and for light boots it does very well; but soft felt cannot add anything to the strength of a sole, and our duty is to make it as strong as possible. Scraps of good leather, skived to a uniform thickness and neatly built to each other, form a strong packing.

Paste all over the insole with thick, strong paste, and lay in the packing, pressing down smooth. Over this brush a coating of paste, and fix on the sole.

Beating the Sole. Before putting on the sole, however, we subject it to some hard treatment. Lift the heavy iron lapstone on to your thighs, smooth face upward; take the broad-faced hammer in your right, and the sole in your left hand; lay the leather, flesh side upward, on the lapstone, and hammer firmly and evenly from the centre of the sole outward. Our object in the operation is twofold—first, to weld the fibres of the leather together; second, to give the sole a smooth surface on both sides.

Shaping. Another point should be mentioned here. In heavy boots the sole is put on just as it is with, of course, the necessary paring; but light boots and those to be finely shaped have soles skived on the under side of the shank, a broad crescent on each side thinning the leather towards the edges.

Laying on the Sole. Laid evenly on, the sole is tacked down, a tack in the centre of the toe, one in the middle of the sole, and two at the end, near the seat of the heel, securing it firmly. Now brace the boot between the knees, and hammer smooth and flat all over the sole. Turn the boot top up, and take a cold iron and smooth down the welt, setting it at right angles with the upper.

Paring. Our boot begins to take shape, and the thought is an inspiration for the deft and delicate work of paring and shaping. All round, and at toe and waist especially, the sole stands out rough and rugged. Those rough edges and corners are to be cut off, but be sure you realise what is to be aimed at in the cutting. Many a million boots have been spoiled in the trimming. Mark lightly the outline of the sole with the back of the knife, and then, with wrist braced, and fingers steadily guiding the blade, cut away the rough edges round the sole, and show what a fine shape it was designed to be. That is good art and fine craft, and now we pass on to the art which conceals craft—make the channelling that conceals the sewing of the sole to the welt.

Channelling. This is not a simple matter of drawing a line round the edge of the sole; it must be graduated from $\frac{1}{16}$ in. at the sides to $\frac{1}{4}$ in. at the shank. Having drawn the lines with a pair of dividers, take the knife in the right hand like a pen, slant the point into the sole, and make a cut on the line that raises the surface of the leather. Deepen the channel with the slanting blade of the prick-stitch, and lift the flap wide, so as to be out of the way of the stitching awl. Turn over the boot, and run the fudge wheel along the welt, as a guide to stitching.

Stitching. If it be desired that the stitching should be shown up, make a thread of yellow flax, and wax it with white wax. The thread should, in any case, be formed of the finest hemp, and waxed sparingly. Set the boot, side up, between the knees, and bind firmly in position with the belt over the shank and under the foot. With the stitching awl, make a hole through welt and sole, bringing the point of the awl out in the channel cut in the sole, and so begin the work of stitching. The rest is obvious, and further detail is needless; but a hint or two may be of service. When about to make a stitch, set the curve of the awl against the upper and the point on the flat of the welt, drive the point quickly through the leather, bringing the elbow down with the stroke, lifting the elbow again to withdraw the awl. To aid the awl, the left thumb should push the sole at the moment of the stroke against the point. As the wax wears off the thread, always renew it on the side furthest from the boot, so that none of the wax may fall on the upper and spoil the work. After stitching, the channel is closed over the stitches.

Building the Heel. The leather for the heel must be hard, thick, and firm in fibre. For

34. SEWING IN THE WELT IN A HAND-SEWN BOOT

an ordinary square heel, we require a seat-piece, two pairs of lifts, and a sole-piece. Cut wide, so as to cover the heel-stitching, the seat-piece is pegged on and made square with the end of the sole. Next, the pair of split lifts have to be placed.

Making Splits. Split lifts are formed out of a solid piece of butt leather, 1 in. broad, 7 in. long, split into two wedges by a simple process. Lay the leather flat, holding it down with the left thumb in the centre. Put the knife into the head of the strip near the outer edge, and make a slanting cut down almost to the other side; then draw the knife evenly down, and the leather will be split in equal wedges. Soak the splits in water, and bend the ends together vertically, and they will form a ring with the inner edge curling. Hammer down the raised edges, and a heel-piece will be formed.

Laying on Split Lifts. Rasp the seat-piece roughly, and cover with paste ; lay on the split lift, and tap down with the hammer ; repeat the process, and put on the second split lift ; pack in the centre with leather. Now put on the solid lifts and top piece, pegging them down. Thus firmed, the heel is ready for sewing. Except that the heel is harder and deeper than the sole, there is no difference between welt sewing and heel sewing. The awl, of course, is straight.

Shapes of Heels. No one knows the variety of taste there is in regard to heels except a bootmaker with a good class of trade. Square heels, round heels, high heels, pegtop heels, and many modifications of these puzzle the bootmaker's wits. Let no one imagine that it is merely a question of a different form of heel ; the kind of heel frequently determines the whole character of the boot. A high heel makes a long angle which must be compensated for somehow, or the tips of the toes and edges of the heels are certain to get the whole weight to carry. The last must be modelled according to the height of the heel. There are various ways of doing this, the most common method of accommodating high heels being to shorten the arch of the foot and heighten the instep on the last. Other methods are adopted, but these are special to different makers.

Finishing the Heel. The heel is the last to be made, and the first to be finished. In spite of all our care, the edges of the lifts show, and the ideal heel is a solid block. First round off the top piece with the knife, and then cut the lower layers of leather to an even shape. This is called *knifing*, and the succeeding peening process is an apparent contradiction of it. With the peen, or smooth bar on the nose of the hammer, you make a regular series of dents in the sides of the heel. The short, hard strokes of the hammer, while raising rough dents, has been welding the lifts together, and when the rasp has been applied and has cleared away the dents, a smooth, solid surface remains.

Smoothing Edges. We leave the heel in that state for the present, and take up other parts of the boot. Apply the sharp knife to the shank and sole, clearing away the rough edges and stiff corners, till the outline of the boot runs clean and smooth from waist to toe. Now the edge of the sole has to be peened and rasped in the same style as the heel. Keep the stroke of the peen well in the centre of the sole, for the edges are tender and may be frayed. Similarly, in rasping hold the sole steady with the left hand and rub the rasp firmly along the centre, taking about 3 in. at a time. One side of the rasp is sharp-toothed, and the other is a fine file. With the file side go over all the rasped parts and smooth them down.

Buffing is the next process, and is designed to clear away whatever marks, scratches, or stains the leather may have taken on, as well as to give a new surface. Before the age of machinery, the buffing tool was a piece of glass ; now we have buffing knives—flat pieces of soft steel given a turned edge that scrapes the surface of the leather evenly. Go over the sides of the sole and heel with the knife, making a clean, hard surface.

Sand-papering. We have done with the tools that cut, and take up the rubbers and smoothers and polishers. First of these is the sandpaper, a strong flexible paper covered with sand silicate. Take a bit of this paper about the size of your palm, clothe the tip of the thumb with it, and rub over sole and edges, imparting to the whole of the bottom of the boot a smooth, uniform colour.

Irons. Like our neighbours, the tailor and the shirtmaker, we have smoothing and polishing irons, but between our little irons and the tailor's goose the contrast is very great. Our irons are little metal blocks, an inch in depth, varying in breadth and thickness according to the purpose for which they are designed. The large glazing iron is 2 in. broad, dome-headed, and 1 in. thick ; on the other hand, some of the waist irons are about the dimensions of a common file. A gas burner or a spirit lamp should be near at hand, for heating the irons. Needless to say, the irons must never be made so hot as to scorch the leather, but the caution is one to be kept in mind. When brought to the proper heat, the irons are applied to the waist, the sides of the sole and the heel, and to the top of the welt, rubbing to a firm smoothness.

Inking. Before applying the blackening ink, rub over the parts to be blacked with a little weak ammonia, and then brush on the ink. Now is the time for using the glazing irons. Kept at a good heat, the irons are rigorously rubbed on the surface of the leather, bringing it to a high polish.

Taking Out the Last. The style of finishing depends so much on the taste of the customer and the skill of the bootmaker that it is impossible to do more than give general directions. After the work of polishing and finishing has been done, a very important and troublesome job remains, and that is the taking out of the last. Perhaps the last comes out with little bother, but if it is stiff, get the last-hook. Having cut the laces that held the fronts together during soling, we put the last-hook down into the hole above the heel of the last. Lay the long double handle of the hook on the floor, and set the feet on it, one on each side of the stalk. Grip the boot firmly under the toe with the left hand, and with the right take hold of the back of the heel. Pull hard at the heel, working the toe up and down. In ordinary cases the last yields and comes out ; but sometimes we have long and sore work to get the boot clear, and the reason is not always obvious.

When you have put in the sock soles, blacked and polished the boots, and duly parcelled them for the customer, you are entitled to think that you have performed a service to the industrial world, and, it may be, the world of art as well, though the Royal Academy may not acknowledge it.

Continued

Continued from page 4060

OPTICIANS

The meaning of *optician* as defined by Johnson is "one skilled in optics," which includes not only the making and fitting of spectacles but sight-testing. The business is a very old one, as may be judged from the fact that the Spectacle Makers' Company was established by charter in London as early as 1629. This company still survives, and is one of the City Companies that is trying to retrieve the inaction of a couple of hundred years by devoting its energies to a scheme of optical examination.

Revival of the Business. Of late years a great revival has taken place in the optician's business, partly due to improved methods of sight-testing, and partly to the fact that the importance of correcting errors of the refraction of the eyes is more generally recognised. Formerly, the universal practice, when one wished to obtain spectacles, was to try on a number of pairs one after the other, and to choose the pair which seemed best to correct the failing or ailing sight. Now, however, the application of scientific principles to sight-testing has completely altered the routine. A Sight-testing Opticians' Bill was introduced into the House of Lords in 1906, and had for its object the registration of opticians in much the same way as dentists and pharmacists have been regulated. The Bill, which would probably have had to be much altered before it would have been accepted by the Legislature, was withdrawn but may be re-introduced when the dissensions in the optical industry have disappeared. We mention these points to show that the business of an optician is one which has good prospects of being an increasing one in the future.

Apprenticeship. There are comparatively few persons solely employed as sight testing opticians, the business being more often carried on in conjunction with other trades such as that of a chemist, jeweller, photographic apparatus dealer, or scientific instrument dealer. As a consequence, apprenticeship to a sight-testing optician is not at all general. The youth is usually apprenticed to a business in connection with which the sale of spectacles is a side line, and if his inclinations tend that way he studies and obtains one of the optical diplomas. The youth who desires to be an optician must have a natural taste for mathematics, and must see in figures more than a mere collection of apparently meaningless symbols. He should also have a taste for making models of small objects, and aptitude in mechanical manipulations. The parent should see that the business to which his son is to be apprenticed is a large one, in which not only is a retail trade done but, in addition, a certain amount of manufacturing, apart from the fitting up and repairing of spectacles. A premium of from £20 to £50 will be needed, and this is generally returned in the form of a small salary.

Education. Apart from the education imparted during the course of the apprenticeship, a youth should attend suitable science classes. If in London, he will be able to take a course in technical and practical optics at the Northampton Institute, Clerkenwell, E.C. This institute was the first to establish classes in applied, visual, and physiological optics and optical instrument construction. Day and evening classes are arranged, and the fees, which are moderate, depend on the time devoted and the number of subjects studied. The day course extends over two years, the fees being £15 a year; but as such a course necessitates attendance daily from ten to five on five days of the week it cannot be taken by apprentices. The evening classes are, however, very convenient for those engaged during the day. Optical classes are also held by the Scottish Optical College in Glasgow and Edinburgh, and there are private instructors in London and some provincial towns.

Examinations. At the end of a course of study, it is advisable to sit for a diploma of one of the optical examining bodies. The two existing bodies are the British Optical Association and the Spectacle Makers' Company. The British Optical Association was established in 1895, and has its headquarters at 199, Piccadilly, London, W. It was the first to establish a complete examination for sight-testing opticians. There are two grades of examination, the dioptric and the fellowship grade, the fees being three and five guineas respectively. Each examination is divided into three sections. In the dioptric the sections are lenses and frames (occupying two hours), subjective sight-testing and dissection (half to one hour), physical optics, physiologic optics, anatomy and physiology, photometry and ethics (four to six hours). The fellowship examination can be taken only by holders of the dioptric certificate. The three sections are practical dissections or microscopic demonstrations (30 minutes), objective and subjective tests (two hours), physiologic optics, embryology and physiology, ethics and etymology, ophthalmoscopy, prismetry (five to seven and a half hours).

The examination scheme of the Spectacle Makers' Company was brought out and the first examinations held in 1898. The scheme

was, in 1904, enlarged so as to embrace sight-testing. As at present constituted, there are three divisions of the company's examination: (1) the special examination; (2) general examination; and (3) sight-testing examination. The first, or arts division, is a written examination in elementary mathematics, light, optics, theory of optical instruments, and heat, with a *viva voce* examination in the use and adjustment of the camera and projection apparatus, the telescope and binocular, the microscope and sextant. Certain parts of this examination are excused to those holding Oxford or Cambridge Local Examination certificates and matriculation or similar certificate; and in the case of pharmacists the examination need not be taken, as they have already passed a more stringent test. The general examination is in three sections: (*a*) a written examination in general and visual optics; (*b*) *viva voce* in the same subjects; and (*c*) a practical examination in the optical analysis of lenses, knowledge of materials employed, and workmanship and frame fitting. The sight-testing examination deals with all sides of the subject of sight-testing and the instruments used. The fees for the three examinations are: (1) £2 2s.; (2) £3 3s.; (3) £2 12s. 6d. The headquarters of the Spectacle Makers' Company are Temple House, Temple Avenue, London, E.C. These examinations are the favourite ones with opticians as diplomates can take up the freedom of the company and of the City of London on payment of £4 4s. and £1 1s. respectively. A freeman may become a liveryman of the Company on payment of £22.

Capital. The ambition of every young optician is to have his own establishment; but before doing so he should take care to enlarge his experience in practical work as much as possible. It is advisable to serve as an assistant in at least two positions, and the modern tendency is to let at least one of these be with a large "store" so as to widen the ideas as much as possible. An assistant who has been only in a small retail business has often little grasp of the extent of the trade done in the palatial store businesses of the present day.

Business Premises. In regard to the best position for an optician's shop this may be considered as following the rule of businesses depending on public support. By that is meant that the best positions for other businesses are also the most suitable for the optician. When the business is solely devoted to that of a sight-testing optician, the shop need be only of modest dimensions, but a good space is required for the testing-room and a smaller room will be needed as a workshop. The space available will largely influence the apportionment of these various departments. For instance, it is not difficult, by screening a side of the shop partially, to carry on sight-testing in the same room as serves for retailing, and in many cases the workshop portion is advantageously carried on in a part of the shop.

Capital. The amount of capital required may be stated at £250, but the beginner should bear in mind that an optician's business is slow in growth, and that it will probably be three years before he can judge of the progress he has made. For this reason it is well on taking premises to stipulate for a three years' agreement, and not to enter upon a long lease. The agreement should contain a clause giving the tenant the option of taking out a lease at an agreed rental. The following is how the capital can be roughly apportioned:

Window fitting and outside signs ..	£20
Shop fitting	40
Stock	100
Testing-room fittings	10
Testing appliances	15
Work-room appliances	5
Advertising	10
Working capital	50
	£250

The outside of the shop of an optician is usually painted in black and gold, or at least, some dark colour. There is a tendency to create new titles for the optician's shop which, in the infancy of the business, is not altogether to be regretted. Some opticians give their premises such titles as "Ophthalmic Institute," "Sight-testing Parlour," "Refraction Rooms," but as long as the public can be made to understand what is meant it is quite open to the optician to invent any title he may choose.

Outside signs in the form of large gilt spectacle frames are good for appealing to the public. Such a sign costs from 20s. to 40s. Enamelled copper spectacles (costing from 3s. 6d. to 10s.) may also be affixed to the window in addition to a small amount of copper lettering. A popular ornament for an optician's shop is the coat-of-arms of the Spectacle Makers' Company, or the crest of the British Optical Association. These are obtainable in cast iron, painted in colours, or as glass tablets illuminated in colour. The last-named are frequently placed inside the window along with, or in place of, the optician's diplomas, which the beginner should possess.

Window Display. The diplomas issued by the examining body are handsome productions, and, if exposed in the window, are calculated to impress the public. The interior of the window is arranged with either ebonised fittings or draped with purple velvet. Formerly there was a dearth of suitable articles for window display, but of late years the problem has been amply solved by the wholesale houses. Among the window attractions may be noted models of the human eye (costing from 5s. to 40s.), charts of the eye, wax busts and faces upon which spectacles and eyeglasses are fitted, and cards showing spectacles in various stages of manufacture. The last-named applies particularly to pebble spectacles, lumps of Brazilian crystal also forming a great attraction. Prismoidal glass blocks of various colours have become a recognised ornamentation of the optician's window. These are obtained in sets costing about 30s. per dozen pieces. Folders and spectacles are displayed on velvet stands which cost from 1s. each, and sets of lenses showing the various kinds are

instructive, or, at least, impress the public with the fact that the construction of spectacles is not so simple as it looks. A Crooke's radiometer never fails to attract passers-by, and it is difficult to convince some people that light is the only agency that spins the vane. An astigmatic clock always attracts. Window tickets and a handful of artificial eyes complete the severest fitted window, but the practical man will not omit to show such things as reading lenses, eyeshades, lorgnettes, motor goggles, and spectacle cases.

Fittings. In regard to the shop fittings, the walls may be utilised for the display of charts and diagrams of the eyes, or, better, for showcases, in which goods should be arranged. The counter should be covered by a glass case, in which are shown spectacles. These cases may be used for the stock of spectacle cases and chains, but at all times representative samples should be exhibited so that the public can see that these goods are made in a great variety of kinds. A stereoscope may be placed on the counter; this and some form of zoetrope is often found, particularly in the shops of opticians who sell scientific instruments.

Stock. As regards the stock carried by the optician, a practical man will have no difficulty in apportioning the suggested £110 amongst the following items: Spectacles in gold-filled, and steel frames, folders, astigmatic clips, eye preservers, coloured glasses, motor and cycling goggles, single eyeglasses (rimless, framed, and with gallery), lorgnettes (in celluloid and tortoiseshell), shooting spectacles, pocket magnifiers, reading glasses, tripod magnifiers, linen provers, eyeglass cords and chains, spectacle and eyeglass cases (including chatelaine cases), artificial eyes, eyeshades, eyebaths, and lens cleaners.

Sight-testing Room. This room requires to be from 10 ft. to 15 ft. long, but by using reflected test types, this distance can be halved. The walls should be painted in a dull-lead coloured paint, and there should be no pictures to distract the customer who is having the sight tested. The test charts are hung at one end of the room, and the patient sits at a distance of 10 ft. away, the chair being advantageously placed on a platform. The test-charts need to be well illuminated, and if natural light be not available in sufficient quantity shaded gas jets or electric light must be arranged so that uniform illumination is given. The most important item in the test-room is the trial case of lenses. The beginner is recommended to spend at least £10 on this item, as upon the accuracy of trial lenses depends subsequent success in spectacle adaptation. Some opticians would include an ophthalmometer as a necessity in the sight-tester's armamentarium. There is, however, a difference of opinion as to the usefulness of this expensive item, so that it has been thought well not to include it in the estimate. The trial case should be placed on a small table by the side of the testing chair. Reading type will also be needed as well as a trial frame, optician's rules, face measures, and prescription book in which to record results. An ophthalmoscope may also be included, and in this case allowance must be made for the ophthalmological lamp, which should be of the wall bracket variety. A hand mirror must be provided for lady customers, who should be given the opportunity of rearranging the hair, which may have become dishevelled during the testing process.

Practical Sight-testing. This will be a convenient place to give an outline or routine adopted in testing sight. The optician should stand beside the customer, who is seated, and should adjust the trial frame on the face, being careful to see that it is comfortable. As each eye is separately tested, an opaque disc is put in front of the left eye. The customer is then asked to look with the right eye at the test chart hanging on the wall, and to indicate which letters he can read. If he cannot read as much of the type as he should be able to, a + 0·5 D lens is put in the trial frame before the eye that is being examined. The customer then indicates whether he can see better or not. If the lens improve the vision, the case is one of hyperopia, and the operator continues to substitute stronger lenses until the one is reached which gives perfect sight. If, however, the customer could not see so well when the weak lens was used, it is changed for a — 0·5 D lens, and if this improves matters, it will indicate myopia, and the operator will proceed to increase the strength of the minus lenses until the proper one is reached. It will be understood that the left eye is afterwards separately tested in the same manner.

Cases occur, however, in which the patient does not see clearly all the radiating lines of an astigmatic chart, and the ordinary spherical lenses must be replaced or reinforced by the cylindrical lenses. The method is similar to that given above, except that the cylinder lenses are used and rotated until all meridians of the chart are clear to the eye. Presbyopia, or old sight, is tested for by the hand-reading type, but astigmatism, hyperopia, or myopia, may also be present, and hence the distance type should also be employed as indicated above. It is not within the scope of this article to include muscle testing, or the objective method of sight-testing. Information on these points is to be found in some of the books in the list at the end of this article.

Workshop. Here the loose lenses are kept either unedged, or of the interchangeable variety. The latter are very convenient, but not universal, hence it is necessary to stock both kinds. Lens testers, opticians' pliers, screwdrivers, soldering apparatus, tweezers, screw extractors, lens drills, a grindstone, and spare parts of spectacles and eyeglasses, are some of the articles which are allowed for in the estimate given. A bench will be needed, and if much mechanical work is done, a lathe, lens surface grinder, and similar larger tools must be added. It is not advisable for a beginner to overstock himself with tools, as the wholesale opticians undertake to do repairs and lens fitting promptly in cases where these are beyond the mechanical skill of the optician.

Advertising. The item included under this head is intended to be spent in developing

the business and in letting the outside public know that there is an optician in the town. Electros of suitable blocks for newspaper illustration or bills cost 1s. each. The distribution of booklets on eye-defects or test cards is an effectual way of advertising. Spectacle lens cleaners (made of chamois leather and lettered with the optician's name), and placing the name of the optician on spectacle cases, are proper methods of advertising. The Spectacle Makers' Company do not allow their Fellows to advertise in a way which may seem to infringe the province of an oculist.

Profits. The profits of the optical business are good, but far from abnormal when one considers the limits which sight-testing imposes upon one individual. Some opticians charge up to three guineas for a pair of spectacles, but such a fee includes the most scrupulous attention to detail in sight-testing, and the finest English workmanship in the frame and lenses. A sum of 15s. to 21s. is, however, usual for a pair of gold-filled folders or spectacles, but steel-framed glasses are supplied to workmen and to the poor at fees as low as 2s. 6d. Prescription work — that is, the filling of the prescriptions of oculists — is a part of the business that is worth cultivating, as not only does such work bring the optician under the notice of an oculist, but it makes the customer return when repairs are needed. On fancy goods such as the optician sells a profit of at least 25 per cent. is obtained, these goods including spectacle cases, lorgnettes, and magnifiers. The business is, or should be, a cash one. It is this feature that makes an optician content with what is otherwise a slow-moving and somewhat tedious business.

Trade and Technical Literature. The following are the chief books and trade journals of interest to opticians:

"The Optician," weekly; "The Dioptric Review," monthly; "The British Optical Journal," twice monthly; Hartridges' "Refraction of the Eye," 6s. (Churchill, London); Taylor & Baxter's "Key to Sight-Testing," 7s. 6d. (Taylor, Birmingham); "Opticians' Handbook," 3s. 6d., ("The Optician" Office;) Druiff's "Refraction," 10s. 6d. (Anglo-American Optical Co.); Thorington's "How to Refract," 7s. 6d. (Rebman, London); Blair's "Errors of Refraction," 2s. 6d. (Bailliere, London); Maddox's "Golden Rules of Refraction," 1s. (Wright, Bristol).

For the academic part of the Spectacle Makers' Examination special books are recommended, a list being given in the syllabus of the examinations.

PAINTERS AND DECORATORS

Painting and decorating is a business in which both artistic and commercial ability should combine to produce a good income and a satisfactory position. Artistic ability is essential to the higher grades of the business, though a secondary consideration in more ordinary grades where sufficient guidance is furnished by clients, who may show passably good taste in their selections from ready-made materials. Commercial ability is essential to success in all grades of this business, for special reasons. First, there is an extremely busy season during four or five months of the spring and summer, a moderate season of one or two months in the autumn, and a universally slack season for four or five months in the winter.

Organising the Work. In these circumstances a good organiser will constantly aim at modifying the extremes, often securing, by judicious argument, the indulgence of his client as to time for the commencement of work, enabling him to maintain with fair regularity an efficient staff of men upon whose services he can depend to carry out the operative part of the business with credit and profit. Bad management in this detail would involve the necessary employment of unknown workmen at critical times. In estimating the cost of work, also, there is a point which the indifferent manager may overlook, and that is the wear and tear of brushes, tools, and plant, which should be charged on an average at from $7\frac{1}{2}$ per cent. to 10 per cent. of the separate net value. Another point of commercial value is the economical management of material. So important is this point that in some large successful firms a special clerk is engaged to watch and record the use of materials only.

The Composite Business. The business pays well in the season if well managed, but the winter slackness has to be reckoned with and in one way or another provided for. Sometimes another business is run in conjunction with painting and decorating, such as plumbing, which is usually busy when painting is quiet. Some of the most successful concerns, however, have been built up without the aid of any other trade, except such as may be described as auxiliary to that of the decorator.

The employment of competent workmen to effect the operative part of the business will give some concern to the beginner. Personal supervision of work in progress is always advisable, either by the master or by a competent foreman.

Capital. On the subject of capital, an important point is that it is usual to extend a term of credit to a very considerable section of the trade's supporters—namely, house agents, whose custom is to have current accounts, and to pay quarterly, or at other periodical intervals.

Contrary to the usual run of shopkeeping, capital in this trade is not wanted *chiefly* for goods in stock for sale, nor for materials to be used on the work, but will be required to pay the wages of operatives while work is in progress. Wages in the painting trade average from 65 per cent. to 75 per cent. off the net cost of the work, which may not be returned for some months.

It has been said that a small business could be started on a capital of £60. From the foregoing particulars it will be clear that the sum named would suffice only for the smallest possible business with barely such equipment as would serve the requirements of two or three workmen at most, without margin for extension of credit and ordinary risk on occasion, and without stocking any materials.

For a concern capable of dealing independently with the average requirements of a moderate class business in the present day, it will be readily admitted that a sum of at least four times that named above, or, say, from £250 to £300, should be available.

Credit. A partial set-off against the credit to be given is that when a business is well established the manufacturers and merchants who supply the trade offer similar credit for materials used. It follows, therefore, that with reasonable good fortune a business should adequately finance itself after, say, the first year, with reasonable progression.

A considerable part of preliminary outlay will be for painters' brushes, tools, and scaffolding, such as step-ladders, planks, long and short stave-ladders (for outside painters' work), hand-carts, etc., none of which will be directly chargeable to any client's account, and can be recovered only by the charge of a proper percentage already named for indispensable wear and tear. It must also be remembered that the master is responsible, under the Employers' Liability Act, for the safe condition of all scaffolding, and must be prepared to compensate any workman who may receive injury through defect therein. This is usually covered by insuring, and the premium paid must be charged to the account for maintenance of scaffolding.

Preliminary expenditure on materials may be limited to the needs of the workshop, as the modern custom of keeping little or no stock of paperhangings or other decorative fabrics, now mainly sold from the attractive pattern books supplied (freely as a rule) by the merchants, leaves the investor free to apply that capital in other directions.

New Work. On account of special conditions as to weekly payments, up to about 80 per cent. of the value of work accomplished being usually negotiable for painters' work on new buildings, beginners find this class of work a convenient stepping stone to more desirable engagements. But the same ready money prospect also operates in the cutting down of prices, until the older firms decline to tender for new work as there would be no profit out of it to them, while the smaller master would probably work personally with his staff, and by watching every point of vantage or chance of leakage with a zeal not to be expected from the best of foremen, may secure a profit at a price lower than would be accepted by his competitors.

Showroom. A minor business such as that quoted at £60 may possibly be conducted without the establishment of a showroom, but not so the moderately good class business, with a progressive future. It has already been mentioned that the modern custom of selecting wall-papers and other decorative fabrics from the handsome sets of pattern-books supplied by the wholesale merchants has largely displaced the old custom of keeping a varied stock of saleable (and unsaleable) goods.

The higher class goods are made up in large "stand" books that may be displayed in an upright position on the floor of the showroom. For convenience of carrying to clients' own addresses for selection to be made, some merchants supply also a smaller-sized pattern-book of the same contents, and this will rest on the showroom table among other similar-sized books containing patterns of the various grades of lower class goods. It is the general custom for the merchants to mark on the back of each pattern the full retail price, from which a substantial discount of 33⅓ per cent. is allowed to the trade, no part of which should, in justice to the responsibilities of the business, be sacrificed to the client.

Both merchants and manufacturers supply the trade in this way, but the merchants will be found the most convenient to the beginner as their selections are made annually from the various manufacturers' productions and arranged in harmonious "sets," thereby presenting great variety. Their pattern-books are distinguished generally by vague titles, such as "Royal Court" wall-papers, or other fancy name, the identity of merchants being known only to the trade. Every pattern inserted in the books is kept in stock during the season—extending generally from September of one year to September of the following year—and sometimes a successful pattern may be carried forward from one season to another.

Showroom Fittings. The walls and ceilings of the showroom should be decorated with different materials in a variety of styles to show, say, three methods of treating a drawing-room, the same number of dining-room schemes, and a fewer number of schemes for other apartments as space may allow, separating these into sections by the use of mouldings that may be shown as samples of panel, picture, dado, or other mouldings used in similar positions occasionally by the decorator in the conduct of his business. These sectional examples should each be a display of good taste and careful workmanship, to inspire confidence in the customer as well as suggesting suitable modifications and colour harmonies, blending or contrasting, brilliant, medium or subdued in tones, light and airy or deep and rich, as occasion may require. Examples of painted woodwork should also be found in some variety in every showroom. These may take the form of doors, panelled on both sides, and hung upon posts between the sections of wall decoration so as to swing either way and display suitable varieties of painting in harmony with the wall schemes. One side of a door may be finished in a variety of grained woods, such as oak, mahogany, walnut, pitch-pine, maple, etc., as the painted imitation of these woods will be occasionally called for.

Fitments, such as a "cosy corner," where clients may sit while selecting their wall-papers, etc., and an arched screen between showroom and office, from which artistic drapery may hang, and in which ornamental stained glass or leaded lights may be effectively displayed, should find room when possible, because it frequently comes within a decorator's province to recommend and supply such fitments to

complete the decorations of a house. These are usually white enamelled with good effect. The screen need not be higher than seven or eight feet, allowing ventilation and light over the top. In front of this screen there may be brass rods, fixed several inches from the wood over which sample rolls of wall-papers may be hung for display when required.

A long, low table with shelves underneath, for the display of smaller pattern-books, colour studies, etc., a few comfortable chairs, and the indispensable good carpet or linoleum on the floor practically completes the up-to-date showroom.

Special Discount off Showroom Goods. It may be noted that manufacturers and merchants to whom the decorator will give his orders for wall-hangings will usually supply all necessary wall-papers, relief materials, etc., for the decorative display above recommended, or to be fixed upon the showroom walls and ceiling, at the exceptional discount of 75 per cent. from list prices.

Shop Window. It is generally to the advantage of a good class decorator's business to make but little display of goods in the window. A white enamelled screen dividing the window from the showroom may be made to support a simple pleated curtain of unobtrusive art shade as a background, and a linoleum of subdued contrasting colour on the stage flooring, with one stand pattern-book opened at a pleasing decorative scheme, showing perhaps a deep attractive frieze with harmonious filling, and maybe a yard or so of rich brocaded silk draped over one end of this, will as a rule impress the right people in the right direction for good class business far more than a heterogeneous assortment of many samples. A pretty and always attractive addition to the window display is an ornamentally-designed easel, upon which rests a picture or a small-scale drawing of an interior, drawing or dining-room, billiard-room, hall, or other example of decorated work in colours, which may be obtained from the trade journals or from special artists if the decorator does not produce such drawings himself.

Wall-paper Stock. Where business prospects reasonably demand the keeping of a stock of wall-papers, this stock should generally be confined to the more ordinary kinds and lower qualities, in the sale of which there is less fastidiousness to contend with than in the higher-priced goods for best rooms.

The manufacturers and merchants quote specially low prices for "stock" orders, in "bales" of stated quantities, as a minimum total. This compensates the decorator for special risks and enables him, when his stock patterns are selected from the pattern-books, to net an extra profit, while losses upon remnants costing, say, from 2½d. to 6d. per roll of a dozen yards—of which the average room requires from seven to ten pieces—will never amount to a very large sum.

A moderate outlay on these goods, say £30 or thereabouts, would be adequate for a start and might be made to embrace 70 or 80 varieties in lots of 25 or 30 of each, with a total of about 2,000 rolls in all. These will be renewable as required during the current season, and renewals should always be compared for exactness of shades before placing into stock, and any variation should be kept apart from previous stock.

Enclosed shelves or "racks" will be required for convenient storage of these goods. The carpenter's work for construction of such racks as usually made for the purpose, may be set down at about 50s. per 1,000 rolls it is intended to place in stock. Each division of square shelving should hold about 30 or 50 pieces for careful and economical manipulation.

Sale-shop. In connection with a good class business in large towns there is very little cash trade usually carried on over the counter in the form of sales of materials only, though when a stock of paperhangings is laid in it becomes a paying department in a district where there is a considerable section of the public accustomed to buy these goods, arranging elsewhere for fixing. This is especially the case in country market towns.

Ready-mixed Paints. A profitable addition to this department will be a stock of ready-mixed paints in lever-top tins of saleable sizes, such as, 1 lb., 2 lb., 4 lb., and 7 lb. These are obtainable in various qualities from most paint manufacturers. A good quality sold at a fair price will be the most profitable in the long run, as the commoner qualities have poor covering power, and are apt to become viscid by remaining in stock.

Paints ground to a stiff paste in linseed oil, such as white lead, ochres, umbers, reds, blues, greens, etc., may be likewise saleable, and could be kept underneath the sales counter in small kegs, covered with a little water (renewed daily), and a small wooden spatula kept in each would serve to supply the required quantities. A horizontal scale or spring balance for weighing these will be required.

Oddments of Stock. Painters' oils and varnishes will form other items of probable sales in this department. These are sold by measure, usually by the gallon, half gallon, quart or pint. In varnishes the sales will generally be confined to three or four varieties, such as pale and hard oak varnishes, black Japan, stains, etc. Makers supply these made up in small sized sealed tins, for convenience of sale. Painters' oils and spirits are not put up in this form, and must be sold from bulk.

Painters' brushes, tools, and sundries are likewise saleable stock, and may generally be of cheaper qualities than used by the trade workmen, as those who buy for a mere temporary purpose can seldom be induced to pay the price of the quality necessary to the expert.

Glass-cutting may also be a profitable branch of the sales department, but would be best conducted in the workshop.

Profits. It will not be found profitable to conduct this business on a margin of less than 33⅓ per cent. gross—that is, one-third of the selling price—to represent profit, which is the

trade discount officially arranged by the merchants and manufacturers in pricing their pattern-books.

Workshop and Stores. The store and paint-shop may be together or separate; the workshop is better separate where space permits. They are usually situated in back premises, and should be convenient for delivery and despatch of heavy loads by horse vans, with, if possible, a good yard for storage of long ladders, planks, scaffolding, hand-carts, empty paint casks, etc., and a "lime-pit" for slaked "putty lime" (used in repairing plaster work prior to painting and paperhanging, and for lime washing); covered sheds are usually provided for these items. In the stores, shelving, in several tiers above a bench, fitted around the walls may contain all the dry colours—in tins or strong paper bags, as delivered, the more expensive coloured pigments ground in oil and turpentine, such as lakes, siennas, vandyke brown, drop black, and decorators' large tube-colours, also the stock of varnishes, enamels, and the like, while from hooks in the ceiling should be hung the reserve stock of empty paint-kettles.

Storing Stiff Paints. The heavy paints for ordinary use ground to a paste with linseed oil, such as white lead, ochre, umber, reds, blacks, driers, etc., may be stored under the benches, where they are easily obtained as required by opening the kegs, keeping a little water on the top of the paste to prevent it drying, and with a trowel or strong wooden spatula in each. A good spring balance should find a place on the bench, so that every article taken out may be weighed and booked, together with the name of the client or job for which it is taken, the same care being taken to book all returns, with similar particulars, adding the dates in each case. Near the scale on the bench should be a small desk, on which is always to be found the "workshop day book," specially reserved for the entries just named, from which the general bookkeeping of the business may from time to time be accurately made up. In the centre of the store a square table covered with baize should be reserved for glass-cutting, and in a safe corner racks provided for glass.

The workshop should be fitted with benches with one or two shelves above, and drawers beneath, occupying two sides of the room, preferably with north and west aspects, as it is desirable to avoid direct strong sunlight for paint mixing. Some pigments are of a more or less gritty powder, and occasional grinding of these call for the provision of a paint-mill (small hand-power cone mill), usually screwed down on the bench of the workshop, and also of a paint-slab, with a stone "muller" or hand-grinding stone upon it. A good slab is one of thick plate glass, ground to a very level surface, and set in a bedding of cement or white lead putty, with its frame bevelled off, and screwed down to the bench. A granite cobble stone cut into halves will make two good mullers or grinding stones.

Oil Storage. In a corner of the workshop or stores a place must be found for three oil-tanks, or a stillage on which the export barrels may be placed when received. The former is the best plan, as there is sometimes leakage and loss from keeping the oils and turpentines in the wooden barrels as supplied by the merchants, due to shrinkage of the wood. Each of these tanks may contain from 50 to 150 gallons of liquid, and is fitted with a tap near the bottom for drawing off the oils as required. One will contain raw linseed oil, another boiled oil, and another turpentine, all of which are indispensable to the mixing of various paints.

In another corner bins are required for the storage of whiting and plaster. These should be in the driest corner and kept dry by being slightly raised from the ground.

A *pickle cask*, large enough to hold from 10 to 20 paint-pots and kettles, should find a place under one of the benches. In this a solution of strong soda or caustic soda should be kept, and dirty paint-pots be placed in it as returned from operative work. They may be removed the following day, and will easily be made fresh and clean by washing in clean water to be ready for further work.

Smudge Pots. Any old paint mixed and returned as surplus from work done should be carefully saved, and emptied into receptacles kept under another bench for the purpose. These receptacles are called *smudge pots*—one is reserved for white, another for pale colours, another for dark colours—and within a reasonable space of time the contents of these smudge pots may be used for ordinary work, or at later periods form good addition to red lead paint for priming new work.

On the shelves above the paint-benches will be kept small jars of all usual paint ingredients, to be handy for frequent use, also palette knives and cleaning rags, of which there should be ample quantity, to prevent wasteful and objectionable untidiness.

On one of the benches small articles such as notice boards, door-plates, etc., may be painted and lettered, also any embossing or gilding on glass may be carried out, while the centre of the workshop may be reserved for pieces of furniture under process of painting, large signboards upon easels, for lettering, etc., and the two blank walls not yet dealt with may be boarded and reserved for sketching out plans of wall or ceiling decorations from time to time, as occasion may require, to facilitate the actual work when operations are commenced.

In the drawers under the paint-benches may be kept the decorator's pencils, tube-colours, palettes, etc., also stencil patterns, gilders' materials, and other small items of value, or for occasional use.

In beginning business, so many articles are required that it is a matter of some difficulty to keep within small expenditure. But by first making sure of indispensable articles in minimum quantities, and by adding small quantities of the remaining requirements, any shortage or omissions can be made up as occasion may require.

Stock for Workshop and Stores. On these lines, the following list may be taken as a minimum stock to start a business where work for at least half a dozen men and one apprentice may be anticipated. The prices are set down at fair averages, though some of the leading items are subject to considerable fluctuations according to rise and fall of markets.

PLANT	£	s.	d.
8 long ladders, assorted sizes, from 10 ft. to 40 ft. length	7	0	0
12 pair assorted step ladders, 5 ft., 7 ft., and 9 ft.	5	0	0
2 pair 9 ft., and 2 pair 11 ft., painters' trestles	1	10	0
3 doz. scaffold planks (2 in.), assorted, 6 ft., to 15 ft. long	8	10	0
2 paperhangers' folding tables and trestles	2	5	0
2 hand barrows, with steel springs ..	11	10	0
WORKSHOP AND STORES FITTINGS (described above)			
Carpenters' work, say	15	0	0
Paint mill, say	3	0	0
Muller and slab, say	1	0	0
2 strong easels, say	1	0	0
Gas, or electric fittings, say	3	0	0
3 oil-tanks, say	6	0	0
Spring balance, and sundries, say ..	1	0	0
STOCK PAINTS, OILS, VARNISHES, BRUSHES,			
Turpentine, 1 barrel (3 cwt.), sa	6	10	0
Raw linseed oil, 1 barrel (3 cwt.), say ..	4	16	0
Boiled linseed oil, 1 barrel, (3 cwt.), say	5	0	
White lead ground in oil, 5 cwt.	6	5	
Zinc white, ground in oil, 3 cwt.	3	18	
Patent driers, ground in oil, 1 cwt., say ..	1	0	
Oxford ochre, ground in oil, 1 cwt, say ..	1	11	
Raw Umber, Burnt Umber, Venetian Red, Indian Red, Brunswick Greens (light, middle, and deep), and vegetable Black, all ground in oil, of each, ½ cwt. (at average prices), total ..	3	10	0
Prussian Blue, Raw Sienna, Burnt Sienna, Vandyke Brown, Orange Chrome, Lemon Chrome, ground in oil, of each, 7 lb. (at average prices), total..	2	15	0
Drop Black, ground in turpentine, 14 lb.	0	14	0
DRY COLOURS.			
French ochres, Venetian Red, Raw Umber, Burnt Umber, Lime Blue, of each ½ cwt. (at average prices), total ..	2	10	0
Indian Red, Lime Greens, Vermilionette, and Ultramarine Blue, of each 7 lb., total	1	10	0
Vermilion (Genuine) 7 lb.	1	5	0
Lemon Chrome, Orange Chrome, Middle Chrome, of each 7 lb.			
Dry white lead, dry red lead, of each 14 lb. total	0	10	0
10 cwt. best Paris whiting	1	0	0
5 gal. (in 1 gal. tins) best copal oak varnish (for outside)	2	10	0
5 gal. (in 1 gal. tins) best copal oak varnish (for inside)	2	10	0
5 gal. (in 1 gal. tins) common oak varnish (hard)	2	0	0
1 gal. (in ½ gal. tins) decorators' carriage varnish	0	16	0
1 gal. (in ½ gal. tins) extra pale Maple varnish	0	11	0
1 gal. (in ½ gal. tins) ivory white enamel (slow setting)	1	1	0
1 gal. (in ½ gal. tins) snow white enamel (slow setting)	1	1	0

	£	s.	d.
1 gal. (in ½ gal. tins) black Japan ..	0	16	0
1 gal. (in ½ gal. tins) Brunswick black ..	0	8	0
1 gal. (in ½ gal. tins) japanners' goldsize ..	0	10	0
1 gal. (in ½ gal. tins) Terebine	0	10	0
1 gal. (in ½ gal. tins) patent knotting ..	0	10	0
WINDOW GLASS			
One crate, say	2	10	0
SUNDRIES			
Putty (best), picked lump pumice stone, of each, ½ cwt.	1	0	0
Pumice stone powder, 14 lb.	0	7	0
Glass paper, 1 ream, assorted sizes, (Nos. 00, ½, and 1)	0	15	0
Powder size, ½ cwt. (best quality) ..	1	15	0
Old oil goldsize, 1 lb.	0	3	6
Gilders' cushions, knife and 3 tips ..	0	3	6
Gold leaf, 5 books; transferred gold leaf, 5 books	0	13	0
Filling up composition, 14 lb.	0	7	0
Paint remover (solvent), 14 lb.	0	7	0
Spirit lamp for burning off old paint ..	0	12	6
Paint strainers, 1 doz. (patent detachable gauze)	1	0	0
Brush holders, 1 doz. (patent suspenders)	1	5	0
Paint pots and kettles, 12 doz. assorted sizes, say	5	0	0
Stencil pins, 2 doz.	0	1	0
Steel graining combs, one set in case ..	0	2	6
12 covering sheets (rough sheeting, 2½ yd. wide, cut into 5 yd. lengths) ..	3	0	0
6 palette knives, 3 putty knives, 3 stripping knives, say	0	10	0
PAINTERS' BRUSHES			
Ground brushes, size 4 0, 2 doz. (oval shape)	7	0	0
English sash tools, sizes, 2, 5, and 8, 1 doz. each (best)	1	16	0
Bevelled varnish brushes, size 3 0, best lily bristles, 1 doz.	3	16	0
Bevelled varnish sash tools, size 5, best lily bristle, 1 doz.	0	12	0
Distempering brushes, ½ doz. 2 knot, 8 ounce, best quality	2	15	0
Stipplers, 2 only, size 8 in. by 6 in. ..	1	8	0
Hog-hair fitches (flat and round), assorted sizes, 2 doz.	0	6	6
Lining fitches, 1 doz. assorted, ¼ in., ½ in., and 1 in.	0	6	6
Stencil tools, 1 doz. assorted ½ in., and 1 in.	0	10	
Graining mottlers, ½ doz. assorted ..	0	6	
Graining overgrainer, assorted	0	3	
Badger softener, size 3 in., best quality ..	0	10	
Dusting brushes, 1 doz.	1	0	
GRAND TOTAL about	170	0	

Totalling up the above figures, and adding the cost of fitting out the showroom and offices, apart from stocking the (optional) sale-shop, it will be seen that the preliminary outlay necessary to the independent conduct of this business in a moderately good way amounts to a round sum of £200, or thereabouts, including £30 for the showroom and office decorating and furnishing, leaving a moderate balance of £100 in the bank out of the £300 recommended as starting capital with which to meet wages and other current working expenses, pending the receipt of cash returns, which should, with good management, steadily add to the capital available for reasonable expansion of the business as the due result of technical and commercial ability on the part of the organiser, upon whom all depends.

Continued

TOOLS

Varieties and Functions of Tools for Cutting, Scraping, Shearing, Detrusion, Abrasion, Percussion, and Moulding

Continued from page 3968

By JOSEPH G. HORNER

A VERY precise classification of tools is neither practicable nor necessary, since much overlapping occurs, specially in regard to large groups of which it is open to question whether they should be considered to operate by cutting or by scraping. A natural generalisation, however, is the following: tools which operate by (1) cutting, (2) scraping, (3) shearing, (4) detrusion, (5) abrasion, (6) percussion, (7) moulding, and (8) measurement.

With regard to the classification just given, though it is a convenient one, yet there is no advantage in adhering strictly to it in a study of tools, which is nothing unless practical. For convenience it is better to regard the processes of cutting, scraping, shearing, detrusion, abrasion, as varieties or grades of cutting operations. For they all have this in common, that they either sever, or remove, or shape material. The fact does not concern the machine-hand that the milling cutter is often a scraping tool, and the emery wheel an abrading tool. The question is, how much metal is removed, and how rapidly, by these tools. And so of others.

Before proceeding with detailed accounts of these tools, however, a brief explanation of their underlying principles will be desirable.

Definitions. The term *cutting tools* is restricted in this classification to those which operate as simple wedges, being incisive in action, or with capacity for getting sensibly under or into the material, and severing and removing a shaving or chip cleanly therefrom. Hence penetrative power is a characteristic of all these tools. *Scraping tools* cannot be classed as wedges, because the front, or leading face, is either perpendicular to the surface being operated on, or it leans over from the perpendicular. Yet there are numbers of tools which operate by scraping that are conventionally and properly considered as cutting tools. *Shearing* is an action which is strictly that of severance in a direction perpendicular to the object being severed. It is in some degree a cutting operation, but is also largely detrusive. But a *shearing cut* is also one in which the movement of a chisel, or chisel-like tool takes place diagonally in relation to the material. *Detrusive* action signifies that of a punch in the formation of a hole, or of a shear blade. *Abrasion* covers the work of grinding. Yet it is a truly cutting action, because the particles which form the grinding wheels are sharp, and penetrate, though to a minute amount, the material which they remove. But, as their action is not wedge-like, they should in strictness be regarded as scraping tools. The foregoing constitute the great group which, for convenience, are regarded as cutting tools. *Percussive tools* embrace the hammer and mallet group. Many cutting tools are, however, invariably operated by percussion, as the axe and adze, the socket and mortise chisels, and others. *Moulding tools* are those which neither cut, nor act by driving, but simply produce outlines that are the counterparts of thei sections, or which are approximately so. The moulders' tools and those used by modellers belong to this group. *Tools for measurement* are second only in magnitude and importance to the cutting group. These have received immense developments in recent years, and will form an interesting study.

Cutting Tools of the Chisel Group. The condition which produces a truly cutting edge is that the faces of the tool must include an angle of a wedge shape, which angle must be less than 90°. Also, the tool in which the faces meet at the lowest angle will have the keenest edge. We know instinctively which of the two wedges A or B [1] would be the more efficient in the actual division of material, leaving out the question of strength for the present. Regarded as a wedge simply, the rule is that the power gained by a wedge bears the same proportion to the resistance to be overcome that half its back does to its height. Or, in simple language, the thinner the back of the wedge, in proportion to its length, the greater is its penetrative power.

Besides the sharp or keen edge, something more is wanted, some other qualities, without which that of mere acuteness of angle is of no value. Those other qualities are solidity, substance, and strength to back up and support the keen edge, out of which arise differences in tool angles; and again, methods of presentation to the material, since it is important that what is termed the *cutting face* of every tool shall stand in a definite relation to the face of the material being cut.

Another fact in connection with the wedge-like tool is that it sometimes acts by splitting, sometimes by cutting; and which process will predominate in any particular instance depends on circumstances. If an axe be driven into a thick piece of timber [1, C], it will not cut at all after its immediate entry, but will make its way by splitting the material to a little distance in front of the edge, so clearing a way for itself by splitting. But if it or a chisel be applied to the removal of a thin shaving, as at D, the action will be altogether that of cutting, the chisel edge penetrating and dividing the material with which it is in actual contact. The difference in the two actions is apparent from the figures, and it is a very important one. Broadly, it

corresponds with the different modes of actuating the chisel, that, namely, by percussion, with hammer or mallet, and that by simple thrust alone.

Chisels. We shall now trace the elementary chisel form through numerous tools in which it is embodied, taking first the common chisels used by woodworkers [2]. In the firmer, paring, mortise, socket, or other varieties, the cutting angles vary but slightly, the difference in the tools consisting chiefly in length, substance, and method of handling. Also, in all these alike the whole of the bevel is imparted to the top or back face; never in the least degree to the front, or cutting face. Directly, whether by design or by inadvertence, that face begins to be *dubbed up*, as the term is—that is, immediately it loses its character of a perfectly flat plane—its value as a chisel is impaired, because it loses the property by virtue of which it is capable of producing a surface perfectly true, and for the production of which the chisel face must be a counterpart of that surface. Hence, in grinding a chisel the bevel is always given to one side only, and in sharpening, the bevel is renewed, or perpetuated on the one side only. For, though the carpenter rubs his chisel upon the flat face alternately with the back, he only does it for an instant, and for the purpose of throwing back and detaching the fine burr, or *wire edge*, that is produced in the act of sharpening, and which, being thus removed, leaves a keen continuous cutting edge.

Other Wood-cutting Tools. The same remark applies to the adze [3, A], which is ground chisel-like, the whole of the bevel being on the inner or upper face. The face which lies against the face of the work is not bevelled. But it is not flat or straight like the face of the chisel, because the adze is not thrust along, o vertically downwards like the chisel. It is swung in a radius, and being used in this fashion, the face is convex, the radius of the face very roughly corresponding with the radius of the circle in which the tool is swung. Hence an adzed surface is never straight, but is formed of a succession of depressions like minute wavelets, differing in this respect from the surface left by a plane or a chisel.

Taking the axes [3, B], we find that there is no flat face which corresponds with the face of the chisel or of the adze, but there are doubly bevelled and equal edges. Hence it is not possible with the axes to produce a true surface in the sense in which it is possible to do so with the chisel, because the guide principle is lacking. And neither of these tools could be used by simply push or thrust alone; the actuating force must be purely percussive.

These elementary ideas respecting the mode of action of cutting tools will be recognised again presently in tools the relations of which to the chisel are not at once apparent. We have two elements—the *cutting face* and the *cutting angle*, the first practically coincident with the face of the material being operated on; the second ranging from 20 deg. to 35 deg. or thereabouts in thinly ground and thickly sharpened chisels respectively.

Forms of Chisels. Looking at the group of chisels in 2, observe the high degree of specialisation to which they have attained since the days of the old bronze users. The firmer, A, paring, B, mortise, C, socket, D, coachmakers', E, or millwrights', carvers, F, and the turners' [4, A], are each different in substance, mode of handling, and of use.

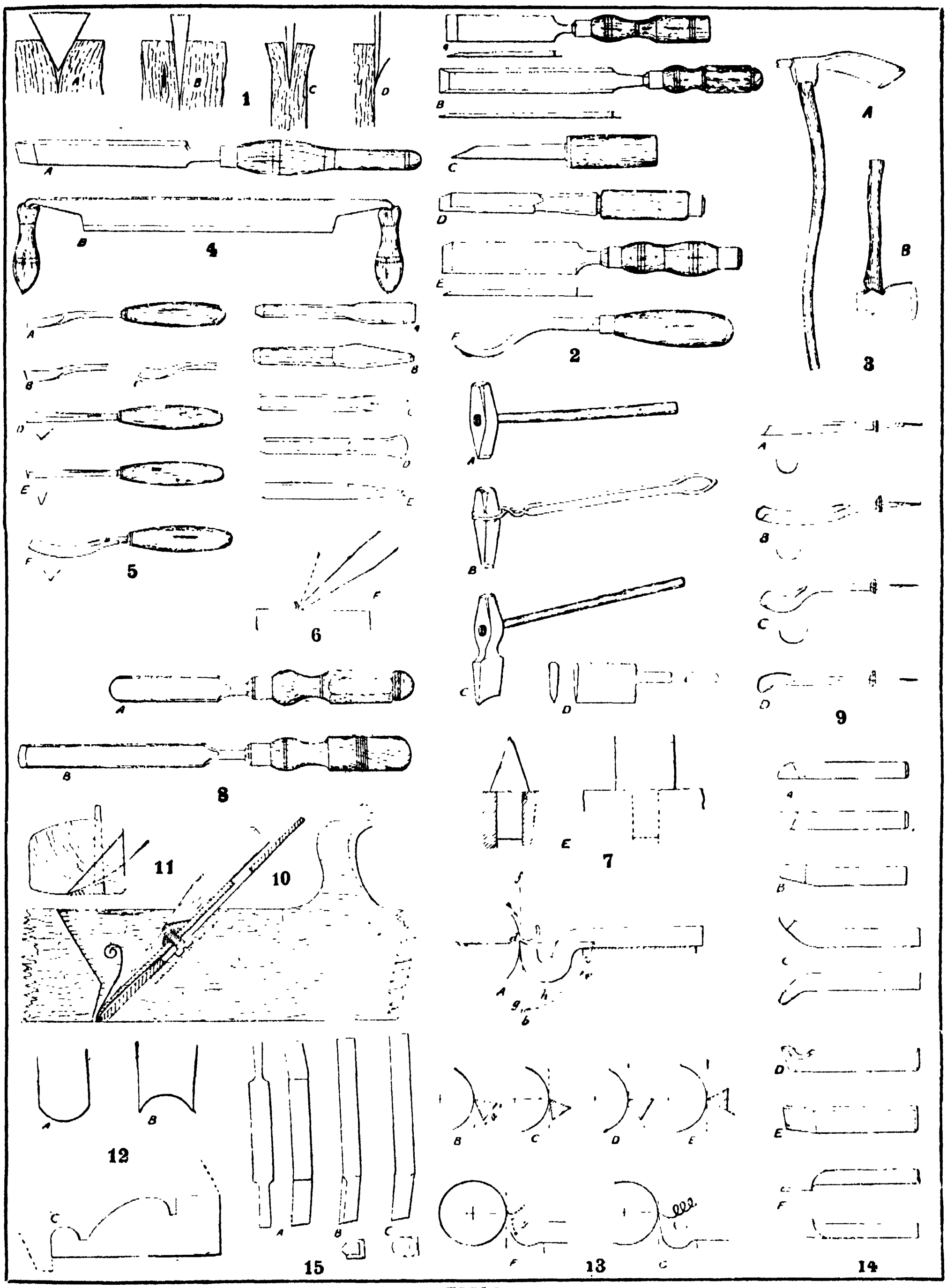
The only difference in the *firmer*, A, and the *paring* chisel, B, lies in the length. They are both thin and light, but the paring tool is about twice the length of the firmer, and is used for shaping over large surfaces, across which the firmer would not reach. The mallet is frequently employed to actuate the firmer chisel, but is seldom used for the paring tools. The *millwrights'* chisels are as long as paring tools, but about twice as stout, and they are employed for the heavy toothed-gearing and other work about mills, for which the lighter chisels would be unsuitable. The *coachmakers'* chisels, E, are a compromise between the millwrights' and the firmer tools, being used indifferently by hand thrust and by malleting.

The *mortise* chisel, C, is, as its name implies, designed for cutting out the mortises in timber, and is always driven to its work with the mallet. The *socket* chisel, D, derives its name from its peculiar mode of handling. The tool, instead of being tanged, as is the case with all other chisels, is provided with a socket into which the handle is driven, in this respect being a survival from the ancient days of the bronze users, for they socketed nearly all their chisels. F is a bent mortise chisel, the *lock* mortise or *dog leg* chisel.

The *turning* chisel [4, A] is a peculiar example, and forms almost a group by itself, the only tools approaching to it in form being the timber scribe, and carvers' corner chisels. It is doubly bevelled like the axe, and its edge is bevelled transversely, so that the tool cuts in a diagonal direction. It is placed at a tangent to the work, and the action when in this position is purely cutting, never scraping. In skilful hands it is a most clean-cutting and efficient tool. A very wide chisel with a single bevel is the *drawknife*, B, used for roughing down edges and narrow faces.

There are a considerable number of chisels made for special trades, the most curious of which are *carvers'* chisels [5], in which, in consequence of the irregular character of the work, various outlines are given to them. The chisels are straight, and *bent* [5], A, and right and left hand *corner*, B, and C. The *vee* tools, D, E, F, or *parting* tools, are like double chisels, and are used for working out vee-shaped grooves and angular corners. These are also straight and curved, and of more or less acute angles.

Chisels for Metals. The engineers' chisels for metal are all formed on the same type as the *cold* chisel [6, A]. This is a doubly bevelled tool, always driven by the percussive action of a hammer, as at F. It does not split at all, but cuts by the edge only, so severing just so much of the material as it is in actual contact with, differing in this respect from the axe and hatchet, which, operating on soft and fibrous timber, split and



TOOLS

1. A. An obtuse-angled wedge B. An acute-angled ditto C. Axe cleaving timber D. Chisel removing thin shaving 2. A. Firmer chisel B. Paring chisel C. Mortise chisel D. Socket chisel E. Coachmakers' chisel F. Lock mortise chisel 3. A. Adze B. Axe 4. A. Turning chisel B. Drawknife 5. A. Carvers' bent chisel B and C. Right and left-hand corner chisels D, E. Straight parting tools F. Bent parting tool 6. A Cold chisel B. Cross-cut chisel C. Diamond point D. Cowmouth or hollow chisel E. Round nose F. Action of the cold chisel chipping metal 7. A, B. Setts, differently handled C. Smith's hollow sett or gouge D. Sett used under steam hammer E. Anvil chisel or anvil cutter 8. A. Outside firmer gouge B. Inside paring gouge 9. A. Carvers' straight gouge B. Carvers' gouge C. Bent gouge D. Back bent gouge 10. A Plane-iron and stock in section 11 Spokeshave in section 12. A. Section of round plane B. Section of hollow plane C. Section of moulding plane 13. A. Typical metal turning tool B. Graver in section, tilted at high angle, C. Ditto at low angle D. Ditto, normal E. Ditto, tilted giving negative rake F Tool with little top rake cutting crystalline metal G. Tool or wrought iron, cutting shavings 14. A. Right and left hand tools for turning or planing B. Right hand off-set tool C. Right and left hand cranked tools D. Double-edged tool or diamond point E. Parting tool F. Right and left hand knife tools 15. A. Double-ended slotting tool B. Diamond point slotting tool C. Round nose slotting tool

divide the grain in advance of the cutting edge. Cast and wrought iron, steel and brass are attacked easily with the cold chisel. Its edge may be straight, or slightly convex crosswise, but never hollow, since that would cause the tool to *draw in*. There are other chisels made on the same principle, but named according to their specific purposes or forms, as the *cross cut* or *cape* chisel [**6**, B], the *diamond point* or *nicker*, C, the *cow-mouth*, D, the *round nose*, E; and the smiths' *hot* and *cold setts* [**7**, A to D], *anvil chisels* [**7**, E], etc., all of which are operated percussively.

There is a group of turning chisels for wood which do not cut at all, but simply scrape, their faces being presented normally to the tangent of the surface of the work. These embrace the firmers, the round nose and side chisels, the hollow chisels, and other tools of special outline, the edges of which are the counterparts of the profiles of ornamental turned work in hard woods, ivory, and metals.

Gouges. *Gouges*, which are a large family, are strictly chisels, differing therefrom only in the plan view of the edge, which forms a curve or sweep, more or less *flat*, or *quick*. Hence the term "hollow chisels" formerly applied to them. Necessarily, gouges are made in an extensive range of curvatures. A gouge of very large radius is flat, one of very small radius is quick; *middle flat* designates some intermediate curves. But there are six series of curves made, so that a gouge of any width can be had in six different curvatures. The widths made range from $\frac{1}{8}$ in. to 2 in. Almost every type of chisel has its counterpart in a corresponding gouge, so that there are firmer [**8**, A], paring [**8**, B], carving [**9**], millwrights', turning, etc., all having the same characteristics as the chisels. There is one other distinction, however, of importance, and that is the division into *inside* and *outside* gouges, according as the bevel of the tool is ground off on the inside or outside sweep. Paring and millwrights' gouges are ground on the inside; firmer, carvers', and turners' gouges upon the outside. The former are therefore used only for straightforward cutting; the firmers and carvers are employed for shaping concavities. The turning gouge operates along a line simply, the work revolving.

Handles. The handling of these tools is that which is best adapted for their special work. The mortise and socket chisels [**2**, C, D] are provided with the stoutest handles of all, to withstand the shocks due to continued and hard percussion; the firmer [**2**, A] and carvers' and parting tools [**5**] are lightly handled, their outlines varying with taste and convenience. The turning tools [**4**, A] have long handles to enable the workman to maintain firm grip and leverage against the shocks and forces tending to throw them away from, and to damage, the work.

Planes. The tools hitherto considered have no control save that afforded by the steady coercion of the workman's hands, maintaining due pressure between the tool faces and the faces of the material. In the planes a great advance is made. Set and coerce a chisel in a *stock* of wood or metal, and we have the plane which produces accurate surfaces, the stock exercising the necessary control. But in the planes we meet with an apparent departure from the principle previously stated that the cutting face of the chisel should be as nearly as possible coincident with the face of the material. The cutting irons of most planes are set at an angle of 45 deg. in their stocks [**10**], the exceptions being unimportant and few, chiefly affecting planes of a special character, and some of those used for hard woods. In the spokeshave [**11**], which is a kind of bastard plane, exact coincidence exists between the cutting face and the face of the material, yet the spokeshave does not approach the planes in value. The reason is apparent. The want of coincidence of the faces of tool and work receives compensation in the planes by the *stock*, the long face of which coerces and controls the iron, rendering its cutting action practically identical with that of a chisel, while the spokeshave embodies the guide principle only in a very minute degree—so little, in fact, that though it cuts sweetly, it is unable to produce accurate surfaces.

The efficiency of the plane, therefore, is due to its stock, in the absence of which the iron, being set at an angle, would be drawn in, and follow the course of the timber grain, curly or otherwise, much as an unassisted chisel tends to do when working lengthwise of similar grain. But it would be impossible to remove shavings and produce a true face on curly stuff if the plane-iron were set like that of a spokeshave; the timber would be torn up whenever the iron met with cross grain. Its action would be too wedge-like, too much like that of a knife. Actually, on very hard and curly material, the ordinary plane has to be set very finely, and used with care, and then to be followed by the scrape, in order to obliterate the marks of the torn up grain; and for this reason planes used exclusively for hard woods are sometimes made of a more upright pitch than those for ordinary woods. For these reasons a plane whose iron should be set at a lower angle than that ordinarily employed would be useless for all except the softest and straightest grained woods. In veneers, which have very curly grain, the surface is prepared for the glue by a toothing plane, with the face of its iron perpendicular to the surface of the work, scraping it absolutely.

Actually, however, the angle of the *cutting face* of a plane-iron is not so high as it might appear to be at first sight. The angle of presentment of the iron is not that at which it is set in the stock, but that at which the bevel is ground and sharpened. The first is about 45 deg., the latter seldom more than 10 deg. or 12 deg., oftener perhaps, 5 deg. or thereabouts, as sharpening is repeated. This, however, would be quite enough to lead or draw the chisel edge inwards without the coercion afforded by the stock.

The Top Iron. Necessarily, the setting of the iron at an angle in the stock deprives its cutting edge of some measure of that support which the true chisel has when its face is

coincident with the face of the work, and so makes the action of the plane approach remotely to that of scraping. But here two agencies come into play; first, the rigidity of the stock itself, secondly, the influence of the *top iron* [**10**]. The latter is screwed tightly down on the face of the cutting iron, almost close down to the cutting edge, and imparts such rigidity thereto that no chatter of moment takes place when cutting. This is one function of the top iron; another is the breaking of the shaving, the shaving curling up the convex end of the top iron with the minimum of friction [**10**]. But when an iron stock is employed, it is usual to employ a single cutting iron only, which also illustrates the influence of the rigid top iron in lessening chatter; for the iron stock is more rigid, more free from elasticity and vibration than the stock made of wood, and there is thus less need to use a top iron, which is often then discarded. We shall meet with this question of rigidity and of curling off of the shaving again in the metal-cutting tools.

The analogy between the plane and the chisel and gouge is seen further in the straight and the profiled forms imparted to the edges of the irons. Planes producing straight faces are the jack, trying and smoothing, the jointer, and panel, the rebates, ploughs, and filisters. The *rounds* and *hollows* [**12**, A and B] produce concave and convex edges; the various *moulding* planes, edges of numerous profiles, C. Difficulties in cutting arise in the last-named, because the proper cutting angle cannot be maintained ta all sections of the profile, and the planes in consequence *drag* and work hard, as do hollows and rounds in a slight degree. But these have been largely displaced by rotary machine cutters, which always act by simple scraping, the faces of the cutters standing perpendicularly to the faces of the mouldings being *stuck*.

We learn from the plane that, provided the action of the cutting chisel is rigidly coerced, it is not necessary for guidance that the flat face of the tool should coincide with the face of the material being cut, as it is in the chisel when hand operated. The control is transferred to the stock. Also, that beyond the wedge form of the tool there is really little in common between the two classes of tools. We have the curling up and free exit of the shaving on one side, and the clearance between the lower edge of the iron and the material, both of which are essential to sweet operation, and there is the essential of rigid fixing. Again, it is of no importance whether the bevelled edge of the iron is lowermost in the stock, as in the wooden planes [**10**], or the plane face lowermost, as in many of the iron ones. The plane will now help us to understand the action of the metal-cutting tools.

Turning and Planing Tools. Although there is no essential difference in the chisels and cognate tools used by the woodworker and the chisel-like tools of the turner and metal planer, yet the work of the latter is more or less a mystery to the former. Acquainted only with the keen chisel, easily operated by the hand, the shaving of hard metal seems to be due to some occult virtue in the material of which the tool is formed; the analogies in form being somewhat disguised, are overlooked. Even so, the constant use of tools for metal working tends to blind the engineers' machinist to the real kinship between those tools and the ones employed by the carpenter; each, however, is akin to the other.

A Typical Tool. Examining now the formation of the tools used for turning and shaping metal generally, the wedge form is still obvious, but it is modified by other essentials. Taking the typical roughing out tool in profile, as used for iron and steel [**13**, A], the *tool angle*, *a*, is a true wedge, though much more obtuse—from 50 deg. to 70 or 80 deg.—than the corresponding angle of a chisel, or a plane-iron. It is, however, no more obtuse than is necessary for its permanence of service. The carpenter's chisel would not endure for a moment; the engineer's tool retains its edge for several hours. The angle *b* is the *clearance* angle, or *bottom clearance*, and should be only just sufficient to prevent such friction between the tool and the work as would involve wasted energy and undue heating. If the clearance angle is made excessive, then, in order to leave a sufficiently thick *tool angle*, *a*, to the cutting edge, the angle *c* of *top rake*, or *front rake*, has to be diminished, and this is an evil. It is a principle that the nearer the line *d e* approximates to the tangent *f g*, or to a plane face being cut, the more nearly perfect is the action of the cutting tool. Actually the angle *b* should not exceed from 3 deg. to 6 deg. for iron and steel, any alteration after this for harder or softer metal being made in the inclination of the line *d e*. For hard steel, and steely cast iron, the angle *c* must be small—in other words the tool angle *a* will be large; for wrought iron and mild steel, the angle *c* will be larger and *a* smaller. In the latter the purely cutting action will be more pronounced than in the former.

The Graver. The facts just stated have so vital a bearing on the efficiency of cutting tools for metals that it is well to put them in another way. A suitable cutting angle or tool angle, *a*, is only one of the essential conditions. Take as an illustration the elementary form of the graver, the old hand turning tool for metal [**13**, B to E]. Its relation to the tool held in a slide rest or tool holder is shown below by the dotted section at F. Now, even though the angle *a* is not varied, very different results will follow with different angles of *presentation*, which will alter the angle of top rake *c*, and that of bottom rake or clearance *b*. Compare with the preceding figure at A. If the tool is raised, as in D or E, it will not cut, but scrape only, and its edge will be rapidly abraded. Or if lowered as in C, though the top face would give more freedom of escape to the shaving than at B, the lower face would have less clearance.

Hence results depend very much upon the manner in which the tool is presented to the work. Though the broad rule is that the top face of the tool should approximate as much as

possible to the plane of the face or surface which is being cut, or to the tangent to the same, this rule is not invariable, since it is modified by the nature of the material. The harder and tougher the quality of the latter, the more essential is the observance of the rule. The more brittle the material, as at F, the less necessary. The reason is to be found in the fact that material which is hard, tough, and fibrous yields shavings which are strong and difficult to break. They come off in long spirals or ribbons, G, often many yards in length. If they can slide off unbroken from the sloping face of the tool the latter is not charged with the extra severe and unnecessary task of breaking up and comminuting the shaving into small chips, but is able to fulfil its legitimate function of dividing or cutting economically. A tool which has to break its chips is subjected to extra strain, and, what is of far more consequence, becomes unduly heated. Rise of temperature limits the cutting capacities of a tool enormously, and, therefore, whatever tends to diminish friction and lessen heat favours its cutting power. The bending over of a shaving without causing its fracture is thus a very important element in a cutting tool. It is seen not only in the metal-working tools, but in the carpenter's planes. The "irons," as we have seen, are set at such an angle that the shavings creep out in continuous lengths.

Solid Tools. The tools used in metal cutting are not usually set in such a way that their axes are in the same plane as the faces of the work. This would be far too inconvenient. The necessary form is imparted by forging and grinding in the case of solid tools. Exceptions to this rule of imparting tool angles by forging and grinding occur in the case of tool points, held in tool-holders, or cutter-bars, and in the case of hand-operated tools [13, B to E], notwithstanding that the essential angles of presentation to the work are alike in each.

Forms of Tools. Again, though copper and lead can be cut and turned with the tools for operating on wood, the case is very different when iron and steel are concerned. The power required to cut hard metal is immensely greater than that absorbed in cutting wood and soft metal. Thus a Whitworth lathe removing cuttings from mild steel at a rate of 50 feet per minute, the cuttings having a section of $\frac{3}{4}$ in. by $\frac{1}{4}$ in., absorbs the enormous amount of power supplied by a 60-horse power electric motor. For this reason the broad chisel edges of the woodworker, represented, say, by a $1\frac{1}{2}$-in. chisel, or by a 4-in. axe or adze, are scarcely used by the metal-worker, except for the finest finishing; the stress and the force required for operating would be too great. Therefore, narrow edges are the rule, not exactly points, but edges of a sensible width, seldom, however, exceeding $\frac{1}{4}$ in. or $\frac{3}{8}$ in. in width when metal has to be removed in considerable quantities, and generally less than $\frac{1}{4}$ in. in width. A group of these tools is shown in **14** and **15**, being straight forward and right and left handed, etc. Many are used on lathes and reciprocating machines alike. Some are special to a particular machine, but however their shapes in plan vary, their sectional forms are based on the principles just explained.

Cranking. What is termed the "cranking" of the tool is quite independent of its cutting action. Its purpose is to prevent the tendency to hitch which is present when the tool is thrown backwards during heavy cutting, which hitching cannot happen when the tool point is in a line with the back of the shank because it then strikes off, in the case indicated, by the dotted line *h* [13, A]. This peculiar function is not so necessary to lathe work where the circular outline of the work receding from the tool prevents risk of a hitch. But in planing and shaping machine tools operating on flat surfaces the tendency to catch is always present, and then the cranking of the tool is a necessity, unless, as is often now done, the tool is made of a very stout section. Another reason is that the labour of grinding is lessened, and the necessity for reforging does not occur so frequently. If the tool were not hollowed out on the top, the repeated grinding of the top face would soon cut out a deep angle into the bar, which would be weak and give trouble. Being hollowed, the top face can be ground many times before the hollow is lost, and reforging required.

By means of narrow-pointed, chisel-like tools formed on these principles the largest majority of engineers' work is cut. By a succession of cuts of narrow width and of greater or less depth, the largest surfaces are operated on. In the width of an inch the number of successive cuts, or *feeds*, will range from about four in heavy tooling to 40 or 50 in very light work. When increased cutting is done it is generally depthwise, *depth of cut*, rather than in width, such being found more economical.

Slowness of Operation. All conditions being equal, the harder the material the slower the speed, and the smaller the quantity of material removed in a given time. It is the principle of work in one of its many applications. Deep cutting at high speed is practicable in woodwork, but not when metal is concerned. The heat generated would be so excessive that the tool would lose its cutting edge almost immediately and become very hot. And the work, too, if of small dimensions would become hot and distorted, so that when it resumed its normal temperature it would not be of correct shape or dimensions. Actually, it would be correct to say broadly that the generation of heat sets the limit to the speeds used for cutting metal with tools of temper carbon. This is very much affected by the forms of the tools themselves, and the efficiency or otherwise of the lubrication adopted; but when all is done that is possible in these conditions the limitations of speed are soon passed. There are certain speeds suitable for cutting each kind of metal or alloy, and though these vary with the conditions just named, they cannot under similar conditions be exceeded to any considerable extent.

Continued

PURE AND IMPURE WATER

Properties of Water. Sources of Supply. Rivers, Springs and Wells. Varieties of Drinking Water. Town Supplies. Impurities. Distribution

Continued from page 4020

By Dr. A. T. SCHOFIELD

WHAT is water? A fluid or chemical compound composed of two parts of hydrogen to one of oxygen, the three volumes being reduced to two in the compound and represented by the formula H_2O, is the theoretical answer. Such a fluid is hardly ever met with in a natural state in all the waters that are found on the earth's surface. Distilled water is sometimes of this composition, but not always. The compound is also pure when artificially formed by electrolysis from the two gases.

Properties of Water. The properties of water are peculiar—it freezes (ice) at 32° F. and boils (steam) at 212° F. It attains its maximum density, or greatest weight, shortly before freezing, at 39° F. It therefore sinks to the bottom, and getting colder rises to the surface again to form ice as it becomes lighter.

The weight of water is 770 times greater than that of air. As we have said, water boils at 212° F. (when the barometer is at 30") and becomes steam and increases to 1,600 times its own volume. In vacuo (or without atmospheric pressure) water boils at 32° F. An increase of 20 atmospheres raises the boiling point to 418° F.

Water has a "skin," due to surface tension, on which many aquatic insects are light enough to move about without getting wet, breaking through it with difficulty. This "skin" is elastic, and tends to contract in all directions. It gives a spherical form to tears and raindrops, so that we get the greatest bulk with least surface. Water has the toughest skin of all natural fluids except mercury; it has also many other qualities, such as incompressibility, of use in hydraulics.

Sources of Water. We now proceed to consider the sources of the various kinds of fresh water, which ultimately come from rain. Rain-water either flows on the surface of the earth or sinks in, and this forms upland surface waters, rivers, springs and wells. It originates in clouds, which are mists formed of water distilled from the sea by evaporation. As the atmosphere is cooled, what is called "saturation point" is reached, and the air can no longer contain the moisture, which collects in drops and descends as rain. If the point of saturation is not reached above 32° F., the water falls as snow [see GEOGRAPHY, pages 294 and 456].

Rain-water is, of course, theoretically pure—that is, nothing but H_2O. It may be so sometimes in the clouds, but is not so as we know it; for, as a matter of fact, it receives many impurities from the lower air before it reaches the ground at all, and thus contains nitrates, ammonia, spores, germs, and various solid bodies, besides salt and sulphuretted hydrogen. As England is an island, the amount of salt in rain-water here is large, amounting to as much as two grains in a gallon, while the nitrates are only ·007 per cent.

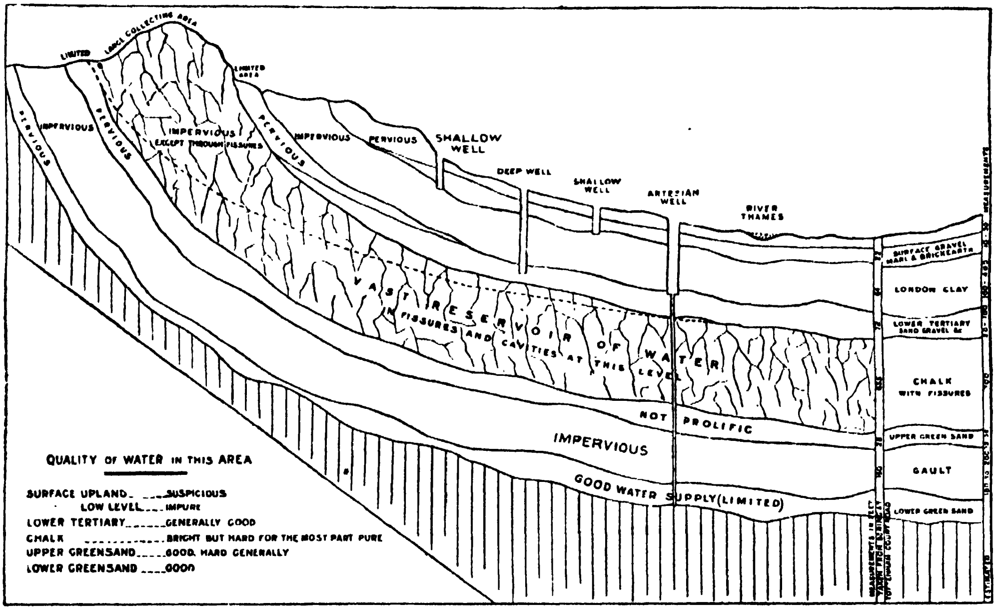
Quantity of Rain-water. The amount of rain-water that now falls is deficient in quantity, but is supplemented by the vast bodies of fresh water existing in lakes, etc., and underground. Even if more were lost the rainfall is not sufficient to supply 50 people per annum. The annual average of rainfall in Great Britain for 20 years is 36½ in.; locally it varies between 20 and 70 in. annually, eastern coasts being the driest, and western hill districts, like the English Lakes, the wettest. To find the quantity of the rainfall, multiply the area of the surface in square feet by half the rainfall in inches; this gives the amount of gallons. One inch of rainfall equals 101 tons per acre. The number of inches multiplied by 14½ gives the number of million gallons per square mile. One inch of rainfall is 4½ gallons per square yard. The rainfall in the wettest year is double that of the driest, and one-third above the average. To find the rainfall on a roof, take the *horizontal* area of the roof, with a slight allowance for evaporation, and apply the rule as above. A roof of 60 sq ft. horizontal measurement with a rainfall of 30 in. per annum will collect 2¼ gallons a day. These formulæ are simple and easily remembered. Rain-water to be drunk must be filtered and stored in a tank, preferably of neither metal nor wood. As rain-water falls it becomes aerated to some extent, which is an advantage. Out of 30 in. of rainfall, nearly two-thirds (19 in.) sink into the ground.

Of course, all the impurities gathered by rain-water as it falls through the lower air are multiplied a hundredfold, until the roof is washed clean. The first water off a roof should therefore always run to waste, and the rest be stored. Automatic separators are ingeniously contrived to effect this. Rain-water is not palatable, and is never a favourite beverage, though some countries have to depend almost wholly upon it. It is best stored in slate, but when kept a long time, as at Gibraltar, Jerusalem, and elsewhere, it is preserved in covered underground cisterns. The capacity of the tank should be two gallons for every square foot of the roof.

Upland Surface Water. Upland surface water we find in lakes and ponds in higher lands. The water is generally pure and soft, but contains a considerable amount (3 grains or more per gallon) of vegetable matter. It is often artificially stored by dams on the moors, and is therefore sometimes peaty in colour and taste. It is

being increasingly used, and is supplied from lakes to Liverpool, Manchester, Glasgow, etc. Though excellent for washing, its chief danger is that common to all soft water—dissolution of some of the lead of the pipes through which it flows. It is probable that, ere long, with the increasing impurity of the Thames, some upland surface water will have to be supplied to London.

River Water. Rivers are naturally pure, and their water is harder than the surface water, but less hard than spring water. There is great danger of contamination from the banks and towns. No river in England is long enough naturally to purify and completely deposit the sewage that falls into it. The natural process of purification is performed by vegetation, which oxidises it by dilution and by precipitation. The deadly micro-organisms (typhoid) which may abound at a sewage outfall, instead of multiplying as they would do in pure water, soon decrease and die out as they are preyed on by the numerous large bacilli that abound in river water. Here we reach a great truth to which we may allude again—*viz.*, that the pollution of a large river by infective germs is of little danger compared with the contamination of wells and streams; in the former the germs tend to disappear, in the latter, to multiply rapidly.



1. DIAGRAMMATIC SECTION THROUGH LONDON BASIN, SHOWING STRATA AND UNDERGROUND WATER
Reproduced by permission from Diagrammettes by W. H. Knight

Springs and Wells. Shallow wells catch the ground and subsoil water; deep wells tap the water stored beneath impervious strata. Shallow wells are generally under 50 ft. deep, but one only 30 ft. deep may pass through rock and tap "deep well" water. The depth of a well is supposed to equal the radius of the circle which it drains, but this varies more or less according to the character of the soil. Shallow well water is very hard, nearly always impure, and often foul from sewage. Deep spring well water is pure, and may be hard or soft.

Artesian Wells. Of very ancient origin in the East, these may be called artificial springs, for where the pressure on the subsoil basin is very great, the water rises at once to the surface, and may even do so in the form of a jet.

A good illustration of the way water lies underground is found in what is called the London Basin [1].

The extent of this basin may be judged when we know that the southern outcrop of the town greensand is at Sevenoaks and the northern at Dunstable, a distance of 40 miles. It is believed that the water of a well in Trafalgar Square, 390 ft. deep, flows into the ground in Hertfordshire. In the chalk there is a "fault" west of Hendon which allows a great deal of water from the chalk outside this area to enter the Thames near Reading; some 300,000 gallons also enter the river daily near Windsor.

All the water in this basin below the London clay is generally good though mostly hard; above the clay it is fouler, at any rate suspicious.

Shallow Wells. All shallow wells in London are now foul and dangerous, and in villages they are often the same.

The best rocks in England for yielding good water are chalk and new red sandstone. The site of a city is generally determined in the first instance by the water supply. Subsoil water varies in height according to the time of year. When it is high, as in March, it is unhealthy; when low, as in October, it is healthier.

Coming now to the country, shallow wells are very common in cottage gardens, which frequently contain two holes only a short distance apart, one in which sewage is stored, and the other from which water is drawn. As the ground is porous, the result is that the water is really dilute sewage, though it appears light and sparkling, and may not even smell till it has stood a little while. It may be drunk for years if no contagious germ has fallen in, for it is not necessarily infectious.

Wells in which the water-level is easily depressed by pumping are the most dangerous, as they will suck water from 20 to 100 times the distance of the depth of the depression. The alteration of the level of the subsoil water is often a danger. When low, the sewage and the well water may remain distinct; when the water rises it may connect the two.

Foul Wells. Pollution of a well depends on:

(1) Its position as to cesspools.

(2) The amount of depression of water-level by pumping.

(3) The porosity of the soil around.

Foul wells show their impurity best after rain, also if the water be kept a short time, or is a little warm. Village wells should be sunk on a level above the source of possible pollution, and at 200 times the distance of their depth from any possible source of impurity. The mouth should be covered, and the well should be level with the neck for the first 30 ft. and fitted with an iron pump. The pump is called a "suction pump" if the water has not to be raised 25 ft., which is about as high as it will rise by atmospheric pressure. It is called a "force pump" when the water is over this depth, and water has then to be "forced" up by pressure. In this case buckets, being cheaper, are generally used.

Deep Wells. Deep wells, to ensure purity, should always be bricked down to the impervious stratum through which the well is lined and through which the surface water cannot pass. This precaution was omitted in a well near Liverpool, bored through new red sandstone, with the result that it drained all the shallow wells around. These were then practically cesspools, and naturally fouled the deep well. An elaborate system of drainage had to be devised, and it was four years before the deep well could be used again.

2. A SAND FILTER

In deep wells nitrates are found, but the water is otherwise pure and quite sterile—*i.e.*, free from all germs. As already pointed out, this is not such a safeguard as it at first appears; for if typhoid or other germs should get access to it, they thrive incredibly, as there are no other germs to destroy them, nor any light or air as in rain-water. The air in water is generally in the proportion of 1·8 parts of nitrogen to 1 of oxygen, a different proportion to that in the atmosphere. This dissolved air gives water a pleasant taste, which is absent in boiled water containing no air; the latter can be made palatable by pouring it through toast.

Drinking Water. Good drinking water should be selected from the purest sources, and should have no taste, smell, or colour. If the quality of water appears doubtful, set a glass aside in a warm, dark cupboard for two days; if it becomes cloudy and smells, it is bad. Water varies according to its source: from alluvial soil it is generally impure; from chalk soil it is generally good, with temporary hardness; from limestone it is good, with permanent hardness; from millstone grit it is pure and not hard; from granite and the primitive rocks it is pure, but may have salt dissolved in it.

Water from springs, deep wells, and upland surfaces is wholesome; that from stored rain and lowland surfaces is suspicious. Shallow well water and sewage rain-water are dangerous.

Water Supply of Towns. We now turn from the varieties and qualities of water to the water supply of towns, which is as follows in round figures:

London	30	gallons daily per head
Edinburgh	40	
Dublin	35	,, ,, ,, ,,
Glasgow	50	,, ,, ,, ,,
Berlin	15	,, ,, ,, ,,
Vienna	22	,, ,, ,, ,,
Sheffield	20	,, ,, ,, ,,

Hospitals have 60 to 90 gallons daily per head.

Four gallons daily per head is the absolute minimum possible, and fifteen gallons daily per head is the practical minimum all round. The amount consumed daily per head is 100 ounces, one-third being in food.

London is supplied with 120,000,000 gallons daily, but 15 gallons per head are lost daily in transit. A waste-detector placed in Lambeth has saved 14 gallons per head per day. The best supply is 25 gallons daily per head for private, and 10 gallons for public use.

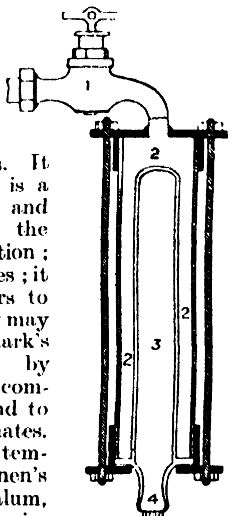
Impurities in Water. The impurities found in water are obvious—a matter of great importance.

Various minerals are held in water termed pure, rendering it thereby *hard* or *soft*. The hardness in water is called *temporary* if it is due to carbonate of lime, and *permanent* if due to sulphate of lime and salts of magnesia. Of course, carbonate of lime in common chalk is insoluble, but with the addition of some carbonic acid it becomes bi-carbonate, which is soluble. $CaCO_3$ (chalk) + CO_2 = Ca_2CO_3 = bicarbonate. This change is effected by rain-water, which contains CO_2, by washing the surface of chalk; hence, to precipitate the lime, all that is needed is to draw off the CO_2 by boiling. This precipitated chalk produces temporary hardness and forms the principal part of the fur on boilers and kettles.

Hard Water. One degree of hardness is due to 1 grain of salt per gallon, as shown by "soap test"; it requires 1 extra volume of soap solution to make a lather; hence 5 volumes of soap solution are required to make a lather in water with 24° of hardness. Each degree of hardness requires 2¾ ounces extra of soap, to make a lather, to each 100 gallons of water. Water up to 20° of hardness is not injurious to healthy people if it be temporary or due to bicarbonate of lime only, though it may be harmful to gouty persons. Water should not, however, for health have above 50° of permanent hardness or sulphates (not deposited by boiling). Water with hardness up to 6° is all called *soft*.

Hard water soon blocks up boilers and pipes, and is a cause of waste in many ways. Nearly one-third of all the tea used in London is wasted by hard water; and Glasgow, when it substituted the soft water of Loch Katrine for hard for washing purposes, etc. saved £36,000 in soap alone per annum. In cooking (especially boiling), the salts get deposited in meat and vegetables, making these hard and indigestible.

The fur in boilers is a source of many troubles. It corrodes the metal; it is a non-conductor of heat and wastes fuel; it coats the food; it prevents solution; it lessens the size of pipes; it allows the sides of boilers to become red-hot, and they may crack and explode. Clark's process softens water by adding enough lime to combine with the CO_2 and to precipitate all the carbonates. But it only removes temporary hardness. Maignen's Anti-Calcaire adds lime, alum, and carbonate of soda, carries down all organic refuse, is said to remove most of the permanent hardness as well, and prevents the crusting of boilers. Professor Nesfield's process purifies drinking water of all organic and dangerous deposits by adding iodine, and then converting this into a soluble salt by a salt of soda. It claims to kill all bacteria in water in one minute, and the water afterwards is clean, harmless, and palatable.



3. PASTEUR-CHAMBERLAND FILTER
1. Inlet of tap water 2. Water chamber under pressure 3. Porcelain chamber through which water percolates 4. Outlet for filtered water

Source of Impurities. Pure rain-water only contains half a degree of hardness. Most rivers are hard; the Thames contains 15°. Hardness in water is bad for gouty people, and maps of the British Isles are prepared showing where the water is hard and where soft, so that people may select their place of residence accordingly.

Impurities in water may be produced (1) at the source; (2) in transit; (3) in distribution; (4) in storage.

Lead and Iron. The first, and perhaps the most dangerous impurity is lead. Permanent hard water soon forms a deposit of sulphate of lead inside the pipe, and thus protects it from being dissolved; but chalky water attacks lead, while soft water soon forms an oxide of lead, which is soluble in water. This is detected at once by adding sulphuretted hydrogen, which produces a brown coloration. The action of water on lead is not yet wholly understood. The soft water of Loch Katrine transferred to Glasgow acts on the lead, and yet there is no poisoning. Heat, pressure, and stagnation favour the action of lead in the water. Proper filtration removes it.

Block tin pipes are needed for *very* soft waters (especially with nitrates), and for all aerated waters. There is a system of adding carbonate of lime to soft water which prevents contamination in lead pipes. This has been done at Sheffield.

Iron in the water sometimes dissolves the lead. If there be more than one-twentieth of a grain of lead per gallon, the water is deemed unfit to drink; one-tenth of a grain may produce symptoms of poisoning. At Claremont, seven-tenths of a grain was found in the water. Cast-iron pipes are, of course, safe.

The purest and softest water and aerated water get most contaminated, also water with excess of organic matter (nitrates) and chlorides.

Organic Matter. Organic matter is either suspended or dissolved in water. It should not exceed 2 or 3 grains per gallon, and may be in one of three forms:

1. Unchanged—dangerous.
2. Consisting of ammonia—less dangerous.
3. Consisting of nitrites and nitrates—harmless.

The nitrogen alone may be also in a fourth form—4·00 gas—which is harmless. There should not be in ordinary water above 1 grain per gallon of nitrites or nitrates. In pure water there is none. Of ammonia (free—*i.e.*, combined with an easily decomposed substance) there must be less than ·05 per million. Rain-water often contains much more. Nitrates are due to animal pollution. When there is much albuminous ammonia—*i.e.*, ammonia in organic substances not easily decomposed, with nitrates, etc.—the cause is vegetable pollution.

Deep wells may contain free ammonia and chlorides without being polluted, but in shallow wells these cause pollution. General solids in water should not exceed 8 grains per gallon, though in chalk they may rise to 14. Sewage water may be clean and drunk with impunity, and is even fattening, if free from pathogenic germs, which cannot be detected. The two diseases most easily conveyed by water are typhoid and cholera. Any oxygen dissolved in water is mixed with it mechanically, as in air, and is not chemically combined.

Distribution of Water. Aqueducts have been used from the earliest ages. They existed in Pompeii 312 B.C. The Romans used inverted syphons to cross valleys; now water is conveyed uphill and downhill in iron pipes in a gentle flow. In towns water and sewage pipes should never be laid together. The former should be

plunged into pitch or varnish, and either glazed to avoid corrosion, or heated to a white heat (1,200 F.); steam should then be passed over it, forming a protecting oxide. The pipes should have spigot joints, rimmed with lead and not with gaskin and tar. Water waste preventers should be fixed to each main to detect leakage. All house pipes are of lead for convenience in levelling, etc., and it is here the danger occurs with soft water.

The largest city in the world (London) still depends on rain-water, and uses one-third of the Thames. It is calculated that of ten glasses of water one at least has been used before; in fact, is dilute sewage. The principal supply is taken at Hampton and stored to settle and clarify in reservoirs capable of holding a week's supply. Five hundred and sixteen million gallons daily are taken by five companies.

Filtration. The water is then filtered through 3 ft. or more of fine sand and gravel [2]. The finer the sand, the fewer microbes pass through it. Ordinary sand lets half through; fine sand, 14 per cent.; very fine silver sand only 5 per cent. The fine sand used to be removed and well washed as needed. The flow of water through must not exceed 30 gallons per square yard per hour. By filtration mere surface water is changed into pure ground water. The newest method of using the sand filter is to allow a jelly-like scum to accumulate over the sand consisting of innumerable bacteria, and constituting a living filter. The crowding microbes on this surface penetrate into the sand, nitrify the organic matter and destroy other and poisonous germs. This surface should not be disturbed as long as the water will pass. In such a filter the sand should be 1 ft. thick, and the water should sink through at the rate of 4 in. per hour.

When such a living filter is in good order 99½ per cent. of the germs are removed. No filtered water should have more than 100 germs per cubic centimetre of water. The water at Altona receives all the sewage of Hamburg, and yet, by filtration, is purer than the unfiltered river Elbe above Hamburg.

In some cases a layer of magnetic carbide of iron is placed under the sand to oxidise organic matter into nitrites and nitrates.

Slate cisterns are good, but they leak; they must not be jointed with red lead, and are often made with grooved sides and set with white lead. This soon leaks; the plumber repairs the leak with red lead, and poisoning ensues. Zinc or galvanised iron cisterns are sometimes used; in this case the iron cistern is dipped into wetted zinc when made. The best supply is a constant service so that no cistern is needed; then no fouling occurs. Screw-down taps are wanted.

The drinking supply should, of course, be separate from that used for closets. Lead cisterns are bad and are most dangerous when new or scraped; wood cisterns are also bad, but stoneware is a good material. The cistern should be dark and well covered.

Analysis of Water. Points of importance to be noticed in analysing water are: Suspended solids, dissolved solids, hardness (temporary or permanent), chlorates and nitrates, ammonia (free or albuminous), absorbed oxygen. Points of minor importance are the fixity or volatility of solids; *loss in solids or ignition*, and the presence of nitrates, sulphates, and metals in solution.

The hardness is decided by the soap test—thus, 70 cubic cent. = 70,000 milligrammes, and as there are 70,000 grains in a gallon, therefore the milligramme is 70 cubic cent. = grains in gall. The soap solution contains 17 grains of Castile soap to 1 litre of water. One cubic centum of this neutralises 1 grain of salts of magnesium or lime.

Chlorine is shown by adding nitric acid and nitrate of silver. One grain of chloride per gallon gives a haze, 4 grains turbidity, and 10 grains a precipitate. The presence of organic matter is shown by the disappearance of the pink colour caused by adding primary acid potash. Free ammonia is revealed by Nessler's test. Lead or copper are shown by adding hydrochloric acid and sulphuretted hydrogen, which gives a brown coloration. There is *no test* for poisonous germs.

Microbes do not necessarily unfit the water for use, but they show the presence of nitrates, which they reduce to nitrites. Low vegetable organisms purify the water and are found in all running streams. Higher animal organisms are also common in pure streams, and, like the ascaris or fluke, may be dangerous.

The following table gives the average analysis of water

CONTENTS.	Rainwater in tanks.		Upland lake water.		Deep wells.		River with sewage.		River at source.	
	Grains in gallon.	Parts in million.	Grains in gallon.	Parts in million.	Grains in gallon.	Parts in million.	Grains in gallon.	Parts in million.	Grains in gallon.	Parts in million.
Solids	4·0	55	4·5	65	35	500	28	406	4·5	64
Hardness ..	—	—	3°	43	—	—	25°	—	4·6°	—
Chlorine	1	13	—	—	3	42	2	30	·15	·6
Nitrates	·7	9	—	—	·9	13	—	—	·03	·44
Ammonia ..	·008	·114	·002	·03	·004	·05	·005	·08	·01	·23
Alb. Ammonia	·012	·172	·005	·08	·007	·1	·0112	·16	·01	·23
Oxygen	·052	·743	—	—	·03	4·2	·19	2 7	—	—

Continued

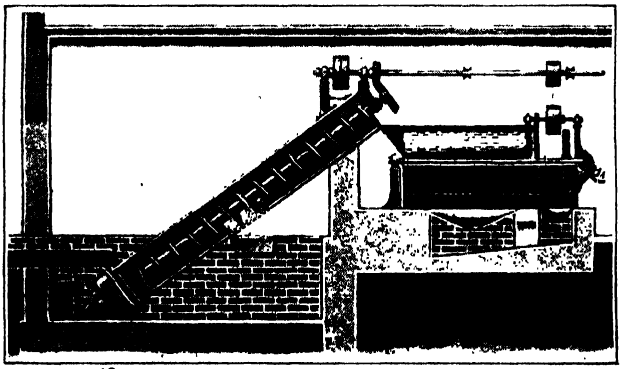
continued from page 4049

BEET SUGAR MANUFACTURE

Processes in Making Beet Sugar. Extracting Sugar from Molasses. The Beet Sugar Factory. Candy and Caramel. Invert Sugar

From Beet to Beet Sugar. The outline for the process of manufacturing sugar from beet is as follows: The beets are washed from adhering earth and stones, and then, by means of an elevator, sent up to a machine which slices the beets into pieces resembling vermicelli. The slices are then put into large iron cylinders and "diffused" with hot water, by which means the sugar is obtained in solution. This sugar solution is then mixed with about 2 per cent. of lime and carbonic acid gas passed into it. A chemical reaction takes place, and carbonate of lime is thrown to the bottom of the vessel, taking with it most of the impurities. The liming is repeated, and sulphurous acid gas passed in; another precipitate then forms, and leaves a clear liquid, which is evaporated until sugar is thrown out in a similar way to that followed in the case of cane sugar manufacture. The divisions into which the subject can conveniently be divided are: (1) washing and slicing, (2) diffusion, (3) saturation, (4) evaporation and (5) crystallisation.

Raising the Beets to the Washers. The beets are conveyed to the washing tanks by bucket elevators, scoop-wheel elevators, or screw conveyers [10]. The *bucket* elevator is not much used, at least in modern factories, as the grit and earth from the beetroot cause a disastrous amount of wear on the buckets and chains. The *scoop-wheel* consists of a long enclosed wheel, with a series of scoops on the circumference. The beets are conveyed down a channel to the bottom of the wheel, and are caught by the bottom scoop. The wheel of scoops revolves, and as each scoop takes up its quantity it passes higher up, and is replaced by the one behind it. When the scoops reach the top of the wheel their contents are automatically thrown into a channel which conveys them to the washing machine. To lift the beets to, say, 18 ft., the wheel requires to be very large and cumbrous, hence, if the distance be more than a few feet, the screw elevator is used. The *screw conveyer* is, perhaps, the most convenient means of transporting beets, and is also useful for lifting water at the same time. As will be seen from the illustration, the screw conveyer consists of a heavy hollow spindle with a spiral blade, the whole being placed in an inclined position. A screw conveyer about 40 in. diameter and 25 ft. long raises about 600 tons of beets in 24 hours.


10. SCREW CONVEYER FOR ELEVATING BEET

The Washing and Slicing Machines. Washing removes soil and pebbles, which would not only injure the slicers, but introduce much mineral impurity into the subsequent diffusing vessels. The simplest form of beet washer is known as the *whisk* washer. It is fitted with a stirring gear consisting of a central shaft to which vertical arms are attached. The vessel in which the stirring gear is attached is of wrought iron, open at the top, and fitted with a perforated bottom, through which earth and stones fall. Underneath the washing machine there is a discharge arrangement for the water, and the stone trap is fitted with a manhole for cleaning out the stones. Another form of washer consists of a perforated drum, into which the beets are put, and which revolves in a water trough fitted with discharge arrangements like the whisk machine.

After washing, the beets are conveyed by an elevator to the slicing machine on an upper floor. This elevator may be of the bucket variety, in which an endless chain of buckets is employed.

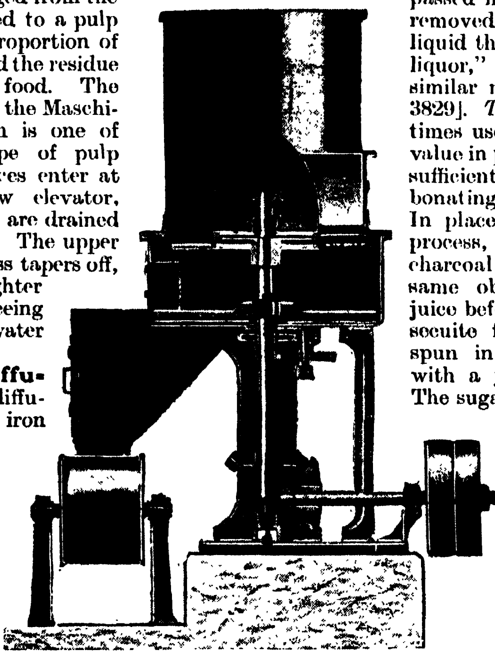
The slicing machines cut up the roots into "cossettes," or slices. A useful pattern is shown in 11. Extra sets of cutter-boxes and knives should be ordered with the machine.

Diffusion. Formerly the beets were rasped to a pulp, the juice pressed out in hydraulic presses, and the solid mass dried by centrifugal machines. Schützenbach then suggested macerating the dried roots in warm water, but this comparatively slow process was replaced by the diffusion process, on the suggestion of Dubrunfaut. The sliced beet is conveyed to the diffusion battery by a band conveyer. Fig. 12 shows a battery in a series of twelve diffusers arranged in a circular manner, the one shown being fitted up by the Compagnie Fives-Lille. The hopper at the top revolves, and feeds the diffusers in turn with cossettes. Diffusion batteries are also arranged in straight lines of twelve or fourteen diffusers. The method of discharging the diffuser varies, but the bottom discharge for exhausted beets is preferable, as

shown in 13. Dr. Pfeiffer's patent discharge is effected by means of compressed air. As soon as one cell of the diffuser is charged with cossettes, it is shut down, and warm water run in. This water takes up some of the sugar, and is then passed into each of the other diffusers in turn. The smaller cylinders shown outside the circle of diffusers are called calorisers, and reheat the water, which, as it passes from the diffusers, loses much of its heat. The exhausted beet is discharged from the diffusers, and is conveyed to a pulp press, where a large proportion of the water is removed, and the residue left ready for cattle food. The spiral elevator press of the Maschinenfabrik Grevenbroich is one of the most modern type of pulp presses. The spent slices enter at the bottom of a screw elevator, and in passing upwards are drained of much of the water. The upper part of the elevator press tapers off, and presses the slices tighter and tighter, thus freeing them of most of the water they contain.

Continuous Diffusion. In continuous diffusion the diffuser is an iron cylinder, and contains a perforated iron cylinder 4 ft. in diameter and 36 ft. long. The axis is formed by a smaller cylinder, and between the two is a helix. The inner cylinder is revolved at such a rate that beet slices travelling along the helix take about one hour to go the whole length. The cossettes are continually immersed in water, which enters at one end, at 86° F. The conditions for good diffusion are fulfilled when the cossettes and water move in opposite directions. This type of diffuser is stated to require but little attention, and less labour than the battery type, but it has not yet come into general use. The temperature in the diffusers is maintained at 70° C. to 75° C., but this is not enough to kill the germs of fermentation, which often cause much trouble. To prevent incipient fermentation, antiseptics are added to the beet chips. Hydrofluoric acid in the proportion of two to six grains per hectolitre has been recommended by Verbiese, Van Voss improving on this by using ammonium fluoride. Sulphurous acid, and aluminium bisulphite have also been advocated as suitable antiseptics. It is the presence of enzymes in the juice that causes its darkening, these enzymes acting as carriers of oxygen.

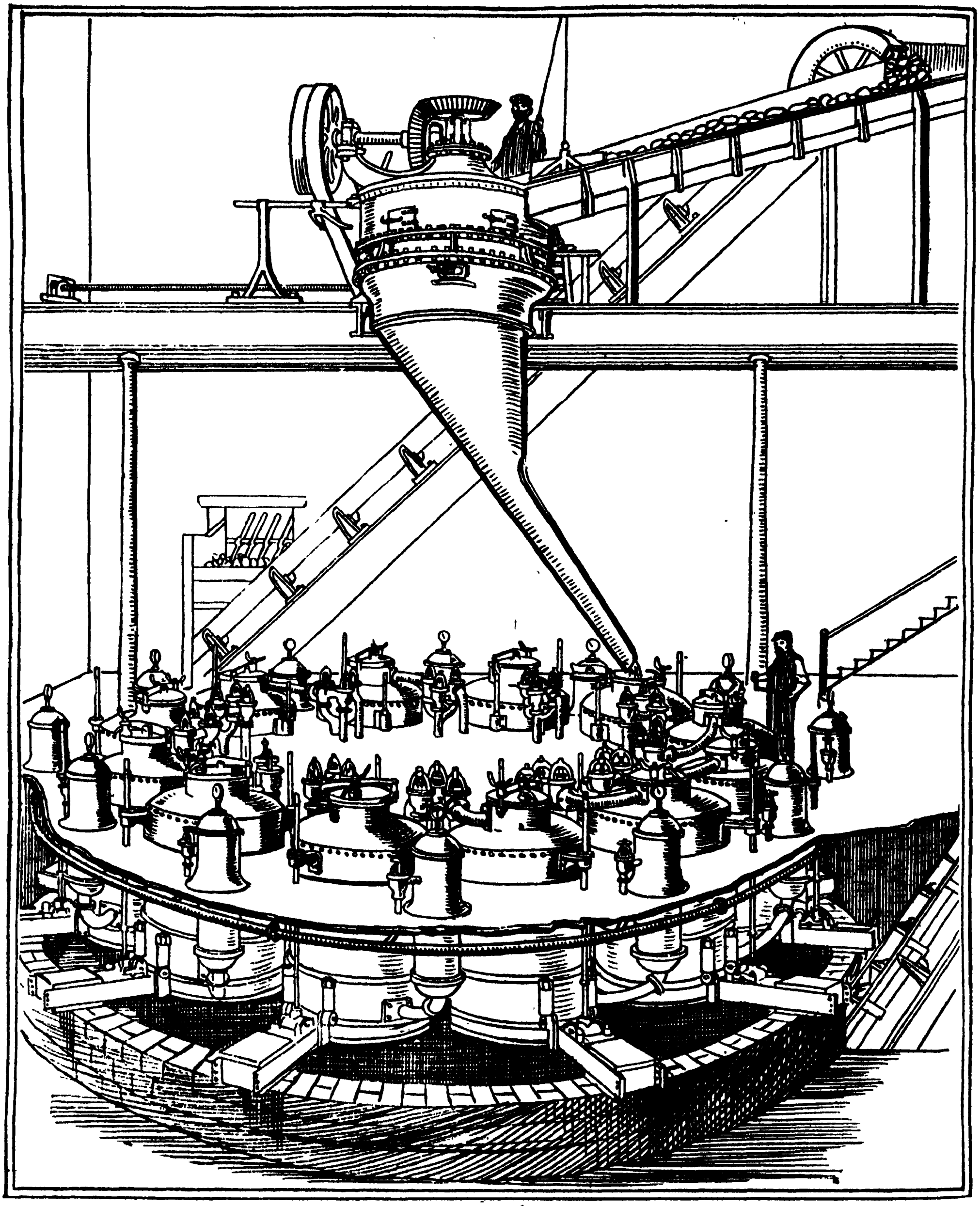
Saturation. The juice is conveyed to the saturation tanks where two to three per cent. of lime is added in the form of milk of lime. The juice is then submitted to carbonic acid gas, this process being called *carbonatation.*



11. BEET SLICER

Double and Triple Carbonatation. The precipitate that falls takes down with it many of the impurities in the juice, and the heat that is applied sends up a scum. The clear liquid is decanted, the scums and sediment being filtered in a filter press. The clear juice is again treated with a smaller quantity of lime, carbonic acid gas passed in, and the resulting precipitate again removed. Finally, sulphurous acid gas is passed in and the sulphide of lime removed by filtration. The clear liquid that results, known as "thin liquor," is next evaporated in a similar manner to cane juice [page 3829]. *Triple carbonatation* is sometimes used, but while it is of great value in practice, it is not considered sufficiently superior to double carbonating to warrant general use. In place of the sulphurous acid gas process, filtration through animal charcoal is sometimes done with the same object of obtaining a clear juice before evaporation. The massecuite from the vacuum pans is spun in centrifugals and washed with a jet of steam to whiten it. The sugar resulting from this treatment is termed *first jet.* The liquid that flows from the centrifugal contains the molasses and is reheated, filtered through charcoal, and evaporated. When spun in the centrifugals the sugar yielded is known as *second jet.* The molasses is treated a third or fourth time and smaller quantities of *third* and *fourth jet* sugar obtained. The final molasses is treated for the recovery of the sugar by special processes described later.

Carbonic Acid Gas. The carbonic acid gas used in carbonatating is obtained by roasting limestone. The kilns [15] in which this is done are either separately fired with coke or constructed to deal with coke and lime in alternate layers. The interiors of the kilns are built of firebrick and cased with iron plate. The carbonic acid gas is drawn off through two pipes near the top of the kiln and the gas is then passed into a cooler and washer. The kilns are charged from the top with lime or lime and coke. The gas washer is a cylindrical vessel; the gas enters near the bottom and meets a shower of water which falls from near the top of the washer. The gas finally leaves by an outlet at the top of the vessel to be pumped into the beet juice. The Sangerhäuser Actien-Maschinenfabrik have a form of washer in which the gas is led through narrow streams of water which drip from projections inside the washer. The points to bear in mind in regulating the limekiln are to use lime as free from alumina and silica as possible; to use a coke giving

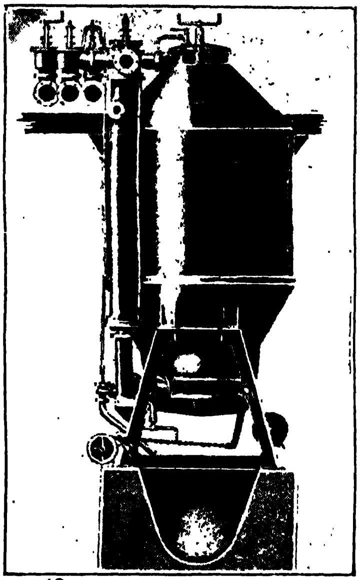


12. CIRCULAR DIFFUSER

as little ash as possible, say a maximum of 7 per cent. of ash ; and to see that the charging be done regularly. Sometimes, from indifferent charging, the charge lodges on the sides of the kiln, this being known as *scaffolding*, and if the air be not properly regulated free air will be mixed with the gas, or if too little be admitted carbon monoxide will be formed. Air in the gas may also be due to leaks in the kiln.

Sulphurous Acid-Gas. Sulphurous acid gas is given off when sulphur is burnt in the air. It exerts a powerful bleaching effect on the beet juice. Special iron furnaces are made for generating the gas, the upper part in those made by the Maschinenfabrik Grevenbroich being fitted with a water-jacket to prevent overheating. Sulphur is fed in at the top, and combustion is started by inserting a red-hot iron and kept up by passing in compressed air. The fumes, known as sulphurous acid gas, are pumped direct into the beet juice at the stage indicated above.

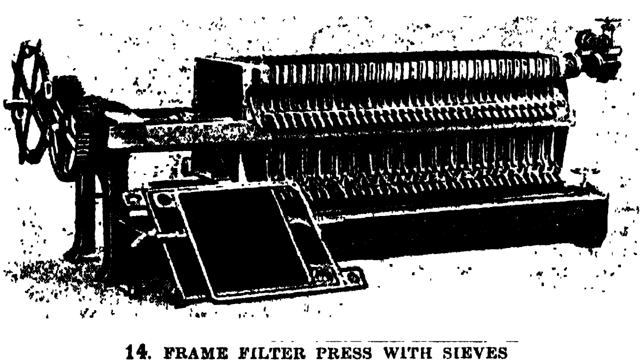
Lime. The quicklime removed from the limekiln is used in the sugar factory for making milk of lime. This is usually done in brick tanks, but special lime-slaking machines are sold for the purpose. Sufficient water is used so that when all action has ceased the lime is still covered with water. Before being used the lime is diluted with water to make milk of lime. It has been found that slaked lime formed in the presence of large excess of water is inferior to lime which is dry slaked, and that solution of sugar is an improvement on water alone as it tends to preserve the lime. Some workers recommend dry-slaked lime to be added to the beet juice instead of milk of lime, but others allege that darkening of the juice results from using the solid.



13. DIFFUSER WITH BOTTOM DISCHARGE

Saturation Plant. Carbonatation and sulphuration are carried on in square saturators, either sunk in the floor with working valves controlled from the top or so arranged that the valves are in the front of the apparatus. The carbonic acid gas is admitted by valves, and there are also provided steam coil, inlet and outlet valves, and juice valves. Saturation with sulphurous acid gas is conducted in similar saturators which are connected with the gas supply from the sulphur furnace.

Filter Presses. The horizontal type of filter press [14] now so largely used consists of a heavy cast-iron frame, supporting a number of square plates by means of projections on the sides of the plates. The square plates are corrugated on the surface, and upon each plate is placed a filter cloth. A series of these plates is screwed tight together by means of levers, and then the sugar-juice is pumped or forced through the press by means of a central conduit. The pressure sends the clear juice through the cloths, leaving the sediment on the cloth in a cake. In another form of filter press now generally preferred, the juice enters at the corners of the filter plates. Other types of filters are [illegible] Taylor filter, the Danek filter, which wor[illegible] pressure, and the Claritas filter, which is designed for filtration without pressure. Sand filters should also be mentioned, as they are a cheap method of obtaining clear sugar juices.



14. FRAME FILTER PRESS WITH SIEVES

Special machines are made for washing the filter cloths. These consist of a cylinder in which is a revolving shaft carrying paddles.

Dupon devised a purification process for beet juice in which baryta replaces some of the lime, but Kruger regards baryta as a dangerous addition.

Purification by Electricity. Several electrical processes have been proposed, some in conjunction with the use of ozone. The combination of ozone and electrolysis is more powerful than either separately; but there seems but little chance of the electrolytic treatment becoming profitable. In one electrolytic process hydrosulphite is decomposed in the juice, and in another method albuminate of barium is used before passing the syrup through electrolysing troughs.

An aluminium process has been devised from which good effects are obtained. It consists in adding aluminium powder to the juice and then ammonium sulphate.

Crossfield and Stein's process for the purification of beet juice, in which peroxide of hydrogen is used, is referred to in the lesson dealing with sugar refining.

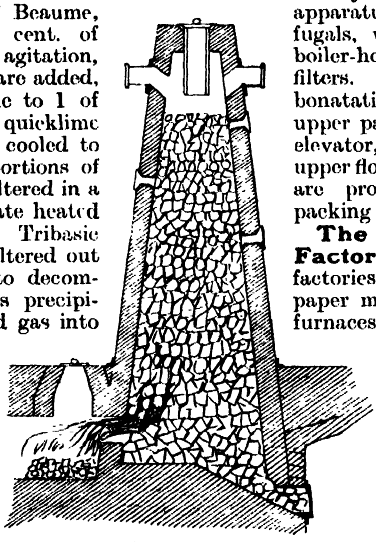
Extraction of Sugar from Molasses. One of the most important problems in the sugar industry is how best to recover the sugar which remains in the molasses obtained in the manufacture of crystalline sugar from cane or beet.

The earliest process was that of Dubrunfaut, who submitted a diluted molasses to the process of osmosis, with the idea of separating the salts that prevented the sugar from crystallising. This method was not profitable to work. The fact that sugar forms a compound with baryta, strontia, and lime has been taken advantage of in separating sugar from molasses. In Schribler and Segferth's processes molasses was mixed with lime, and the saccharate of lime thus formed was separated by alcohol. Bodenbender and Manoury introduced

modifications of this process, but in all alcohol was required, and this is an objection, owing to the price or fiscal difficulties.

The Steffen Process. Steffen eliminated the use of alcohol. He discovered that lime forms with sugar three different saccharates—the *monobasic* saccharate, the *bibasic* saccharate, and the *tribasic* salt. The tribasic saccharate is with difficulty soluble in 200 parts of water, but is quite insoluble in water saturated with the tribasic salt itself. When precipitated under certain well-defined conditions it is granular, and can be readily washed in the filter. The operations in the process are: Forming the bibasic saccharate in the cold; boiling to form sugar and tribasic saccharate; and filtering the tribasic salt. The process is worked as follows: Molasses is diluted with water until it has a density of 6·6° Beaume, equal to from 7 to 8 per cent. of sugar. Then, with constant agitation, small quantities of quicklime are added, in the proportion of 1 of lime to 1 of sugar. After each addition of quicklime the temperature rises and is cooled to 15° C. before adding further portions of lime. The mixture is then filtered in a filter press and the clear filtrate heated for ten minutes at 100° C. Tribasic saccharate is formed and is filtered out and washed with hot water to decompose it. The residual lime is precipitated by passing carbonic acid gas into the solution, and the sugar obtained by filtering and evaporating. It is usual, however, to employ the tribasic saccharate instead of lime for treating raw juice. The other liquors are used for diluting further quantities of molasses and are eventually used as a fertiliser when they become laden with the mineral impurities of the molasses. The Steffen process is equally applicable to the recovery of molasses in refineries, the slight variation involved being in the treatment of the saccharate. The saccharate from the presses passes into the dissolving pans, where it is dissolved by means of sugar syrup which has been saturated with carbonic acid gas and heated to about 70° C.; the sugar solution is then diluted with sweet waters so that it contains approximately 5 per cent. of sugar. After filtration the liquor is fully saturated with carbonic acid gas and treated as above.

The Use of Strontia. Scheibler has since worked out on these lines a process in which strontia is used. Strontium saccharate is formed, separated by filtration, and washed with a 10 per cent. solution of strontia. The warm solution is then cooled, strontia monobasic saccharate and sugar being yielded by the decomposition of the bibasic salt formed when hot. The strontia solution is decomposed by carbonating, filtration, and evaporation. The strontium carbonate is calcined to form the oxide, and this with water gives the hydrated salt, which is used over again.



15. LIMEKILN

Beet Sugar Factory. The cost of a factory for manufacturing beet sugar may be estimated at from £30,000 to £40,000, this sum providing the machinery for working 300 tons of beetroot a day. The factory building would take about a year to construct and fit, and would cost about £8,000. A working capital of about £40,000 is also required for paying for roots and current expenses. Mr. Stein has recently shown a balance-sheet of beet sugar works in which a gross profit of £17,500 is produced on a capital of £80,000 after allowing for depreciation. Such a factory would purchase beetroots from the growers in the neighbourhood. In regard to the general arrangement of the factory the ground floor is usually taken up with the beet-washing apparatus, the diffusion battery, centrifugals, vacuum pumps, beet elevators, boiler-house, limekiln and bone-black filters. On the next floor are the carbonatation apparatus, the triple effet, upper part of diffusion apparatus, beet elevator, and laboratory, while on the upper floor are the vacuum pans. Rooms are provided for storing sugar and packing purposes.

The Waste Products of Sugar Factories. The *bagasse* of cane sugar factories can be utilised as a fuel, for paper making, and as manure. Special furnaces are required for burning bagasse. With a Grundel semi-gas furnace it has been found that when dry bagasse is used more steam is obtained for a similar grate surface, and if the draught be properly controlled an economy of fuel is effected. Damp or a mixture of damp and dry bagasse can be burnt on emergency although there is of necessity a diminished production of steam. Dry cane leaves (trash) are only slightly inferior to bagasse as fuel. Bagasse wet from the mill is commonly regarded as being equivalent in fuel value to from one-fifth to one-sixth of its weight in coal. Bagasse has also been proposed as a food for cattle.

Molasses is used as a fuel, for the manufacture of alcohol, and for feeding cattle. One method of using it as fuel is to sprinkle the molasses on the bagasse on its way to the furnace, or it can be sprayed on the burning bagasse. Animals take molasses fodder willingly and no bad effect has been observed, no purgative action has been noted, and the quantity of milk in the cow fed on molasses fodder is increased, though it does not keep so well. Organic acids specially suited for mordanting wool have been made from vinasse.

Dried *diffusion pulp* from beet-sugar making should be dried before being used as a cattle food, otherwise it tends to bring on certain diseases. *Beet tops* are used for feeding cattle or left to rot in the field as manure. The *waste liquors* from beet sugar factories have also been used as a source of ammonia.

Sugar Candy. Sugar candy is used largely for priming beer and wine in addition to its well-known use as a sweetmeat. The syrup after being filtered bright is boiled in a vacuum pan until the requisite concentration is reached, the point being technically known as boiling to "thread" or "feather." The candy pans or pots have holes drilled in the sides, and threads are stretched across the hole, being filled up on the outside by a mixture of beeswax and resin to keep the syrup from running through. The syrup is filled into the pots, which are then transferred to a store to cool gradually in from 9 to 12 days. The rate of cooling influences the character and quantity of candy formed. The lower shelf or store cools the syrup the more rapidly, but the yield is inferior in quality. This is sometimes corrected by adding more water to the pots on the lowest tier.

Caramel or Burnt Sugar. Caramel is the brown substance produced by the action of heat on sugar or glucose. It is used in very large quantities as a colouring for beverages, gravies, and sweetmeats. The processes of manufacture are based on those of Asrymusry, who gave two recipes—one for the production of rum colouring, and the other for beer or vinegar. For *rum colouring*, take 3 kilos of caustic potash or soda and 6 kilos of water, or 4 kilos of carbonate of potash and soda and 8 kilos of water. Dissolve with heat in a large iron pan, and add 120 kilos of glucose or 130 kilos of syrupy glucose. Boil over the fire till irritating vapours begin to appear, then decrease the heat and stir continuously till the required shade is produced, and stop the process by adding 30 to 40 kilos of water in a fine jet. For *beer* or *vinegar colouring*, 6 kilos of carbonate of ammonia, 6 kilos of water, and 120 kilos of glucose are required, the method of making being the same as for rum colouring. The addition of alkali has for its object the production of a darker and brownish shade, and renders soluble the small quantity of ulmic acid which is always formed towards the end of the cooking, thus enabling a solution to be made from the caramel which is not cloudy.

Salmon and Goldie, who made a research on this subject in 1900, gave the following as a good recipe. The glucose used must be a well-prepared maize glucose. About 5 cwt. of good white glucose is melted in an iron vessel. At a temperature of 95° C., this takes about one hour, and when all the glucose is melted the temperature is raised to 110° C., another 20 minutes being required. Then add 45 oz. of carbonate of ammonia and 15 oz. of chloride of ammonia, and stir occasionally till the caramel is formed, some two hours' boiling being needed. This change is very noticeable, not only on account of the increase in volume of the caramel to about double, but because of the evolution of greyish-yellow vapour, which is very pungent, staining the hands yellow. The temperature of *coming on* is about 154° C. The heating is continued till the caramel is so thick that it can only just be stirred. This takes about another hour, but the time varies. The heat is now turned off, and if solid caramel be required, it is thrown out on to iron plates, allowed to cool, and broken up with hammers. If fluid caramel is being made, sufficient water is added to produce the required density. Heat is applied and the caramel is then passed through sieves to remove any carbonaceous or extraneous matter, and subsequently stored in iron tanks.

Some Modern Improvements. Since this method was published, the only other improvement of importance is that introduced in a patent taken out by Gonville and Jarvis in 1904. These inventors melt glucose or other carbohydrate to a syrup, and run the syrup into another vessel, where it is mixed at the atmospheric pressure with ammonia in solution, or otherwise, without the application of heat. The mixture is then transferred to a third vessel, in which it is heated with agitation to a temperature of about 220° F., at about which temperature and atmospheric pressure it is maintained until caramelisation is sufficient.

Another branch of the investigation of Salmon and Goldie had reference to the addition of alkalies to the caramel at the latest stage of its manufacture. They found that the employment of a small quantity—say, half a pound—of sodium or potassium hydrate to 100 lb. of caramel distinctly improves the flavour, and that it plays an important part in keeping the colour dissolved in the beer in which it is employed.

Analytical Data. Good caramel should conform to the following requirements:

1. The intensity or colouring power of a caramel solution, measured in a Lovibond's tintometer, using a 0·10 per cent. aqueous solution and a 52-series yellow-tinted glass, should show 18 degrees on Lovibond's scale.
2. The average specific gravity of caramel fluid is 1·377.
3. The average copper oxide reducing power, calculated as dextrose, is about 33·87 per cent. of the weight of the fluid caramel.
4. The mineral matter should not exceed 0·80 per cent. of the weight of the fluid caramel.
5. The caramel should not be affected by proof spirit or weak acetic, tartaric, or citric acid solutions, and it should not cloud pale ale.

Test for Caramel. A rough test given by Thorpe for ascertaining the presence of caramel in beer is to add tannic acid. If malt only be present, the colour is precipitated, but caramel colour is not altered. In wines, paraldehyde is used as a test, the caramel being thrown out by that liquid as a brown precipitate sticking to the bottom of the vessel.

Sweetmeat Caramel. Sweet caramel has no connection with true caramel, or burnt sugar, but is prepared by boiling down a solution of cane sugar and glucose syrup to the solidifying point, a hard, glassy mass being produced. About 10 per cent. of glucose is needed to prevent the cane sugar becoming opalescent and granular; but in time, by absorbing moisture, the caramel becomes opaque. To prevent this as far as possible the squares are wrapped in paraffin paper. Vacuum pans yield a lighter-

coloured product than that made in open pans, but in either process the rule of boiling is, "the quicker the better." The mass is coloured and flavoured appropriately.

Invert Sugar, or Saccharum. Invert sugar is an important product in the brewing industry. It is used in beer to improve its quality and stability and as a substitute for part of the malt. Beers in which this malt adjunct is used are preferred by the public, on account of the lighter character and full flavour thus given to them. Invert sugar is prepared by heating a solution of cane sugar with dilute acid or yeast, which causes the constitution of the sugar to be altered or inverted, a mixture of dextrose or levulose being produced. Invert sugar for brewing purposes should possess a full molasses-like flavour, and on this account jaggery is preferred by saccharum makers. A good product can, however, be made from refined beet sugar.

Garton and Parsons, in 1856 and 1859, took out patents for the inversion of cane sugar with small quantities of acid; and Herepath, in 1862, prepared invert sugar by adding 3 oz. to 4 oz. of pure hydrochloric acid to each cwt. of dissolved sugar, maintaining the temperature at between 180° F. and 212° F. for one to three hours. The acid was then neutralised by alkalies, and the product was ready for use in the brewery.

Wohl and Kollrepp's Process. The technical defect in previous processes consisted in the fact that comparatively weak solutions of sugar had to be employed, which necessitated subsequent concentration, with danger of deterioration. There was also a large quantity of acid to be neutralised. Wohl and Kollrepp found that 30 per cent. solutions of cane sugar could be easily inverted, their process being based on the following facts:

1. The rapidity of the inversion of cane sugar in concentrated solution by dilute acids in 40 to 80 per cent. solution at 45° C. to 105° C. is far less dependent on the proportion of the quantity of acid to the quantity of sugar present than it is on the quantity of water. As 80 per cent. sugar solution contains only one-sixteenth as much water for an equal quantity of sugar as a 20 per cent. solution, the complete inversion of an 80 per cent. solution, if this action were independent of the excess of sugar, would only require one-sixteenth as much acid in proportion to the sugar as a 20 per cent. solution, other conditions being equal. Owing to the retarding influence of the excess of sugar about one-twelfth of the quantity of acid required for a 20 per cent. solution is actually necessary.

2. In the inversion of cane sugar with acids there takes place, along with the decomposition of the saccharose and at a speed increasing with the concentration of the sugar solution, a re-formation of products of condensation of the dextrose and levulose, and of both one with the other, which precedes and accompanies the decomposition and colouring, and the speed of which increases more rapidly with the concentration of the acid than does the power of inversion of the latter. Each acid has a very low degree of concentration, at which, when heated for from about a half to one hour at 80° C. to 95° C., it completely inverts a quantity of cane sugar that may amount to as much as about four times the quantity of dilute acid employed without decomposing or colouring the invert sugar formed.

A Working Example of the Process. These investigators calculated out the quantity of acid and the time required for various concentrated solutions of sugar, the following being a working process founded on the facts:

One ton of finely ground white sugar is melted at about 95° C. with 2·4 hectolitres of water in a heated and closed pan provided with agitating mechanism. After cutting off the steam 0·222 litres of pure 38 per cent. hydrochloric acid, previously diluted with 10 litres of water, is stirred in, and the temperature maintained at from 80° C. to 90° C. for about half an hour. The colourless invert sugar syrup is drawn off, and is ready for immediate use.

The vessel in which the inversion is to be carried out should preferably be of copper or iron lined with enamel, and have steam jacket, stirring gear, and means for introducing live steam. About 560 gallons of boiling water is introduced into the inverter, and the temperature maintained at 190° F. to 200° F. by means of the steam jacket. One cwt. of sugar crystals is run in by means of a hopper, and the mixer started. As soon as the sugar is partially dissolved a second cwt. of sugar is added, and the process repeated until a ton of sugar has been dissolved. Next, 13½ lb. of a 10 per cent. solution of hydrochloric acid is run in and mixed, stirring being continued over one hour at a temperature of 190° F. to 200° F. No neutralisation of the product is necessary, owing to the trifling amount of acid in the finished invert. The invert produced is white or only faintly yellow, and is intensely sweet with a flavour like honey. When cold it is a viscous mass, and on standing for some weeks a magma of crystalline glucose separates. One ton of sugar crystals yields 2,357 lb. of invert sugar.

Tompson's Yeast Process. Any commercial saccharose is dissolved in water heated to 95° F. to 160° F. one part of yeast per 100 of sugar being added and allowed to stand five hours. At the end of this time all the cane sugar is inverted. The most favourite strength of sugar solution is 20 per cent., and 130° F. is the best temperature to employ. The yeast is separated by adding sulphate of lime and filtering. This process can be worked to great advantage with low grade raw sugars, but the product is not so well adapted for priming purposes.

The invert sugar solution can be purified by charcoal filtration, as in refining sugar, and concentrated in vacuum pans.

Saccharum is found commercially in the fluid and solid forms; the liquid form is crystallised by seeding it with small lumps of solid saccharum. With sugar at £15 a ton, saccharum can be made at about 12s. 8d. per cwt.

Continued

THE BANK OF ENGLAND

The Special Functions of the Bank of England. The Bank and the Nation. Weekly Return and Reserve. Difference between Long and Short Exchange

Continued from page 3973

By R. LAING

THE important place attained in this country by the second function of banking (the receiving of money on deposit), although fostered indirectly by the legislation intended to restrict note issues [see below], is in the main due to the preference exhibited for it by the general trading and saving community. A reference has been made previously to the transference of capital from one locality to another, and in practice this is done through the branch receiving the deposits of an agricultural district remitting the surplus money held by it to an office in some manufacturing centre, there to be lent out to traders requiring additional capital. If, however, after all such demands have been satisfied, an unexhausted surplus remains, an additional source of lending is brought into operation. All capital which cannot be profitably employed in the country flows naturally, through the instrumentality of the banks, to London, and is there made the means of financing investors in the loans of our needier neighbours and of maintaining London as an exchange centre.

The Employment of Money. As a natural consequence of issue or of deposit, the lending of money at interest follows, as otherwise no profit would be made by the institutions concerned.

The agency of banking in acting as a middleman between borrower and lender has, in some measure, been encroached upon by the rise of joint-stock companies and the facilities given through them for direct investment. One most important section, however, remains unaffected—the employment of money deposited for a short time, pending a favourable opportunity for investment. This is lent through the agency of the banks to the industries which, at the time, are most in need of *temporary* capital.

Every banker in this country is, to a certain extent, a dealer in arbitrage, in receiving for collection documents on other towns and granting drafts on these places, charging, of course, a commission for doing so. In the constant preparedness to do such business, he resembles the Paris dealers to whom reference has been made, and removes what would be, in the absence of such preparedness on his part and on the part of others, an irritating check to commerce—*i.e.*, he saves the B's the necessity of seeking for and bargaining with the A's. The functions of loan and remittance are combined in the discount of a bill payable in another locality.

The function of the safe custody of valuables, which requires no explanation, was in reality the precursor of that of deposit, the care of the client's money following naturally the keeping of his securities.

The Business of Banking. The business of banking is carried on by private partnerships, by ordinary joint-stock companies, and by companies having a certain amount of Governmental privilege and supervision (usually connected with the right of issue). The supervision exercised may reach the point of actual control of the bank's business by Government officials, the directors appointed by the shareholders occupying but a secondary place. In addition, numerous instances will be found of firms or companies who are not considered bankers in the ordinary sense, but who are largely engaged in certain banking business—say, bill discounting, foreign exchange, etc. The operations of any bank depend to a great extent on its clientele and on the locality in which it transacts business—a country banker, for instance, will not deal with shipping business. These operations are further referred to in the succeeding sections.

Space does not admit of a detailed historical resumé showing how the Bank of England (referred to hereafter as the Bank) came to be regarded as the focus and centre of the financial world of this country, but only permits of those incidents and enactments being touched upon which exercise a direct influence on the present-day position.

The Establishment of the Bank. The Bank is the offspring of a political organisation. At the time of its establishment, the reigning monarch, William III, was none too securely seated on his throne. Notwithstanding his undoubted abilities, he had not overcome the prejudices of the Tory party, but had, unfortunately, seriously alienated the sympathies of the districts in which they predominated. He was dependent, to a very large extent, on the support of those trading centres whose merchants dreaded the possibility of the return to power of the Stuart Dynasty, and made it the first article of their political faith to support that which stood to prevent the occurrence of such a contingency. The merchants and citizens of London, the largest of all such centres, having still in mind a scandalous breach of trust perpetrated upon them by a Stuart king, were at once the most important and the most vehement section of the Whig party, and were the means of enabling it, in the divided state of the country, to maintain a front against the power of France.

The Government, in consequence of the ceaseless war expenditure, were never free from financial embarrassment, and, therefore, when at a time of particular gloom a proposal was made for the establishment of a corporation to subscribe in the first place a new loan, they readily agreed to concede to it certain privileges and monopolies in banking.

These privileges were limited to a certain number of years, but this clause was rendered completely inoperative by the never-ending financial predicament of each succeeding Government, the Bank authorities, at each renewal of their charter, being able by some judicious assistance (coupled with that rendered during the period then elapsed) to retain each and all, and even at times to add to their stringency. At no time, as a result of the continual struggle with France, was any Government able to bargain with the Bank authorities on even equal terms, the matter only being brought to a conclusion by the Act of 1844—the arrangement that is at present in force.

The Bank's Monopoly. The practice of banking at the close of the seventeenth century was looked at very differently from the way in which it is now regarded. Deposit banking in its present form was non-existent, and it was deemed impossible to make banking profits without the right of issue, this dogma being so firmly held that, to all intents and purposes, banking and note issue were interchangeable terms. In consequence of this, when it was desired to give the Bank the sole right of corporate or joint-stock banking in England (afterwards restricted to the district within 65 miles of London) it was deemed sufficient to enact, to quote the words of the Act of 1708:

"That during the continuance of the said corporation of the Governor and Company of the Bank of England it shall not be lawful for any body politic or corporate whatsoever, created or to be created (other than the said Governor and Company of the Bank of England) or for any other persons whatsoever, united or to be united in covenants or partnership, *exceeding the number of six persons*, in that part of Great Britain called England, to borrow, owe, or take up any sum or sums of money on their bills or notes payable on demand, or at a less time than six months from the borrowing thereof."

Banker to the Government. In consequence of this privilege and the interpretation accorded to it by current opinion, the only rivals which the Bank encountered in its trading were the private banks of the metropolis, and these, restricted in their number of partners to six, tacitly admitted their inferiority to a large corporate body possessing the support and friendship of the Government, gave up in time, although under no obligation to do so, their own issues, and used the notes of the privileged institution. Although not a State bank in the strict sense of the word, but only an ordinary trading company, it held the privilege already touched upon, acted as banker to the Government, and was regarded by the private bankers as possessing a prestige greater than their own. With the rise of deposit banking, an additional weight was given by the circumstance that when it was discovered that joint-stock banks could transact a profitable business (without the issue of notes) within the restricted area, the banks which then entered the field of operations did not dispute the place they found accorded to the Bank of England, but, on the contrary (the preliminary acrimonious disputes ori inating in the jealous anger of the Bank authorities having been closed), gradually established with it the present friendly relations, *and concluded by making it the depository of their reserves.*

The Country's Final Reserve. The Bank, originally established solely with a view to transact corporate banking and to lend some very acceptable assistance to Government, had already the care of the greater portion of the paper currency of the country committed to its charge; but this action on the part of the other joint-stock banks saddled it with the more onerous duty of controlling and safeguarding the final reserve of this country, a duty which, although never formally admitted by the Bank authorities, claims the closest attention of the Court of Directors.

The Bank's note issue can, however, have but little claim upon their time, the duties of the Bank in this connection having been laid down with great rigidness and exactness by the Act of 1844, which, in effect, converts the Bank (for this purpose) into what is nothing more nor less than a machine. It will be quite sufficient, in consequence, to briefly recount the objects of this Act and the means taken in it to attain them.

The domain of finance is a particularly fascinating one for Parliamentary theorists, and, in consequence of the crises of 1797 and 1825, there existed, at the beginning of last century, a very considerable body of politicians deeply interested in this question. They were possessed by the firm conviction that the crises and their attendant evils were solely due to excessive issues by the country banks, who were held to have encouraged the most reckless speculation. Their £1 issues, circulating largely in the hands of a class at that time uneducated, and in consequence extremely liable to unreasoning panic (in the event of any suspicion arising as to the circulating medium), were singled out for special attack.

Country Banks and Panic. The disease was considered too desperate for cure. The small notes were got rid of, and the Act of 1844 was passed to cripple, and in time destroy, the country circulation—a process that seems to be approaching completion.

The following constitute the chief provisions of the Act of 1844:

1. The Bank of England was divided for the purposes of the Act into two departments, those of Issue and of Banking. The Banking Department (carrying on business in the ordinary manner), is not dealt with by the Act.

2. The debt due by the Government to the Bank, and sufficient securities to make up a total of £14,000,000, were to be taken over by the Issue Department, and that department was authorised to hand to the Banking Department notes equalling this sum. In addition, it was authorised to hand to the Banking Department notes in exchange for all bullion transferred, with the provision that the silver bullion held at any time by it was not to exceed one-fourth of the amount of gold bullion concurrently held by them.

3. Notes at the rate of £3 17s. 9d. per standard ounce were to be given by the Issue Department in exchange for gold bullion tendered to it.

4. If for any reason some country issue lapsed, the Crown in Council was authorised to increase the issue of the Bank against securities to the extent of two-thirds of the lapsed issue. The reasoning on which this provision was founded was the supposition that against such issues an amount in bullion equalling a third of their sum would be held by the issuing banks as a reserve, and would, on the issues lapsing, be thrown into circulation, the net loss in currency being only two-thirds. The authorised issue against securities is now £18,450,000.

5. The weekly return, dealt with later, was ordered.

Country Issues. We now give a list of the regulations with respect to country issues.

1. Issuers restricted to those issuing on May 6th, 1844.

2. Those then issuing allowed to continue, subject to certain conditions.

3. All claiming right to issue to return a statement of their *average* issue for the 12 weeks ending April 27th, 1844, and this to form the *maximum* of their future issues.

4. Penalties imposed in the event of this maximum being exceeded, or of failure to render weekly returns.

5. The Bank of England authorised to compound with those wishing to cease issuing, at the rate of 1 per cent. per annum, all payments to terminate in 1866.

6. Issues lost if issuer became bankrupt, or ceased to issue, or if bank with six or less partners increased the number to more than six. A country joint-stock bank, issuing notes, establishing an office within 65 miles of London (the National Provincial Bank is an example) does so at the cost of the loss of its issue, while if two joint-stock banks of issue unite, the resulting corporation can only retain the issue of one whose name it takes.

7. A yearly licence of £30, payable for each place of issue—four licences to cover all branches open prior to 1844.

8. Any company or corporate body allowed to carry on banking business within 65 miles of London, provided no bills were drawn, accepted, or endorsed by it payable to bearer on demand.

Position of the Bank in a Crisis. No note may be issued under £5. The Bank of England notes, which are legal tender in England (save when tendered by the Bank) are only payable at the office of issue or in London—repayment of a note issued in Birmingham cannot be legally demanded at Liverpool, but it is payable in gold on demand at Birmingham or London.

Subsequent events speedily showed that, whatever merit the Act could lay claim to, its automatic action could not prevent in the slightest degree those recurrent crises (ascribed formerly to excessive country issues) to regulate which was the primary intention of its framers. On three separate occasions (in 1847, 1857, and 1866) the operation of the Act was suspended as the only means of combating the existing panic, and on each of these occasions a continuance of the Act's restrictions would have entailed the stoppage of the Bank.

The approach of anything like a financial crisis at once makes an impression on the Bank's reserve. Bankers all over the country are called upon to grant loans or to repay deposits (with a consequent withdrawal of their balances at the Bank). As the tightness increases, so do the demands on the Bank—the increased demand for settlement of debts in cash requring an enlarged circulation of currency. The notes of the Bank of England possess so great a prestige that even in the severest panics this country has known they have been accepted by all as the equivalent of gold. An increase in this universally accepted credit money will, as in the past, speedily combat the effects of a panic, by enabling all solvent individuals to obtain the assistance they require ; but until the suspension of the Act makes it permissible for the Bank to issue without regard to bullion in its vaults, every note issued brings the automatic stoppage of the Bank nearer, and increases rather than diminishes the panic and failures.

The Bank's Weekly Return. Before the operation of the Bank's discount rate can be dealt with, some explanation of the weekly return required by the Act of 1844 is desirable. The following is a copy of that for the week ending February 7th, 1906 :

BANK OF ENGLAND

An account pursuant to the Act 7 and 8 Vict., cap. 32 for the week ended on Wednesday, February 7th, 1906.

ISSUE DEPARTMENT

Notes Issued ..	.. £50,405,050	Government Debt ..	.. £11,015,100
		Other Securities ..	.. 7,434,900
		Gold, Coin and Bullion	.. 31,955,050
	£50,405,050		£50,405,050

BANKING DEPARTMENT

Proprietors' Capital	.. £14,553,000	Government Securities	.. £12,584,867
Rest	.. 3,581,456	Other Securities ..	.. 33,311,131
(*c*) Public Deposits*..	.. 9,638,276	(*a*) Notes	.. 22,171,330
(*d*) Other Deposits ..	.. 41,794,989	(*b*) Gold and Silver Coin	.. 1,620,306
(*e*) Seven Day and other Bills	119,913		
	£69,687,634		£69,687,654

* Including Exchequer, Savings Banks, Commissioners of National Debt, and Dividend Account.

February 8th. J. G. NAIRNE, *Chief Cashier*.

The practice of the Banking Department is to deliver to the Issue Department all bullion held by it, with the exception of about a million sterling (retained as till money), and to receive in return notes of an equal value. The *real* issue (*i.e.*, the circulation in the hands of the public, in the above example) is therefore £28,233,720 (£50,405,050 less £22,171,330). As it is in the power of the Banking Department to demand from the Issue Department coin or bullion for the notes held by it, the available metal reserve of the Bank was accordingly £23,791,636 (£22,171,330 plus £1,620,306). So long as the

Act remains in operation, the Bank cannot allow the total bullion in its hands to fall below the amount of the real circulation less the issue authorised against securities—the amount of bullion in the case given being represented by the figure £9,783,720 (the real circulation being £28,233,720, and the authorised issue £18,450,000). Once the bullion in the vault reaches this point the Bank ceases to do business, no matter how greatly its assets exceed its liabilities, or how readily its notes are accepted, unless the operation of the Act is suspended.

The item of £14,553,000 is the capital of the shareholders, while that for £3,581,456 is the rest or reserve fund of undivided profits (which latter is in practice not allowed to drop below £3,000,000). The liabilities of the Bank to the Government and public are composed of the remaining three items, in this instance amounting to £51,553,178.

The Bank's Reserve. The last item of these three is a small one, consisting entirely of outstanding drafts, and is easily provided for, while, except in time of war, the public deposits occasion, or should occasion, no trouble to the Bank authorities. The periods of collection and expenditure are regular, and the reserve to be kept against them is easily ascertained, while it is safe to assume that the Government will not be forced to withdraw its deposits in time of peace to satisfy its creditors. The variations of the remaining item are not so regular, and one section in particular, the bankers' balances, is very liable to sudden withdrawals.

The Bank's directors have weekly to decide if, in their opinion, and in view of every circumstance, the reserve comprised of items *a* and *b* is a sufficient one to be kept against *c*, *d*, and *e*. The proportion deemed to be safe is not a constant one, and, indeed, it may happen, through an unexpected financial movement, that the reserve formerly considered inadequate may be looked upon as too large, although it has remained stationary, and the Bank's liabilities have at the same time largely increased.

The factors which may qualify so largely the relative amounts are the state of internal trade and of international exchange, while the lever with which the Bank endeavours to keep its reserve at the desired proportion is its Minimum Discount Rate.

Influence of the Markets. But the Bank finds its task to-day by no means so easy of accomplishment as in the past. Then it dominated the discount market of London (at that time without a serious rival or competitor), any change in its rate having an immediate effect. To-day the position is greatly altered. The markets and exchanges of the Continent and America must now be reckoned with; the conditions of exchange, in consequence of the changed circumstances of commerce, are much more complex; it is surrounded by discount institutions with which it does not in ordinary times compete, whose business in some cases exceeds its own, and whose interests may run contrary to its proposed action; the demand for gold has enormously increased; and, while some other markets absorb greedily all metal that flows in their direction, they are by no means so willing to part with it in turn. In consequence the Bank may sometimes be compelled to supplement an alteration in its rate by entering the open market and taking measures to see that the rates obtaining there approximate to its own.

Long and Short Exchange. It is evident that a bill payable 90 days after sight is not so valuable as one which is payable on demand, the difference equalling the discount which the holder of the former bill would require to pay if he desired to realise the draft. The French merchant in Paris in buying a bill on London takes this, of course, into consideration, and, as he is only entitled to take credit when remitting to London a bill at 90 days (instead of one at sight) for the amount his London correspondent will receive on discounting the document, he will require an allowance from his fellow Parisian which will balance matters. The cash value of a bill for £1 payable in London in 73 days, if discount is at 5 per cent., is £$\frac{99}{100}$, and, if the French sight exchange is at 25.25, its cash value in francs in Paris is $\frac{99}{100}$ths of 25.25 = 24 99¾. In the same manner a London merchant purchasing a bill on Paris payable in 73 days will require, assuming sight rate at 25.25 and discount in Paris at 5 per cent., to receive, expressed in the face value of the bill, $\frac{100}{99}$ths of 25.25 francs (or 25.50½ francs) for each £1 in cash.

A change in the London discount rate entails a corresponding variation in the long foreign exchanges, which does not extend to the sight exchanges. An increase to 6 per cent. would, if the sight rate continued to be quoted at 25.25, alter the cash value of the bill for £1 at 73 days on London to 24.94 $\frac{7}{10}$ francs, while a fall to 4 per cent. would result in a quotation of 25.04$\frac{4}{5}$ francs. A *rise* in interest in London allows bills drawn on it at a usance to be purchased for a less amount in foreign currency, and renders unprofitable the resale of bills already held. The rates given are quite arbitrary, and in actual practice stamps and other factors enter into account.

The Effect of Bank Rate on Market Rate. The interest allowed by bankers and bill brokers in this country on deposits lodged with them varies with the Bank's discount rate. Any rise or fall in the Bank's rate is reflected in the deposit rate and consequently in the discount rate of the open market, competition tending to keep the margin of profit between these two rates uniform. A rise in the Bank's discount rate (implying a rise in interest rates all over the country) is, however, regarded by the trading community as a most disagreeable check on industry and production, only justified by the existence of some dangerous tendency, which cannot be defeated save by means of such an agency.

One striking difference between the practice of banking on the Continent and in this country is the prevalence of foreign exchange business there compared with the absence of it here. This statement seems, at first

sight, to be ridiculous, but what is meant is that, while a Manchester banker will not hold a bill on Paris in his bill case, but will forward it at once to London for collection or sale, a Paris banker will retain a Manchester bill until maturity should it be worth his while to do so. Again, the British manufacturer or merchant has no wish, as a rule, to indulge in the speculation of exchange. All his calculations are based in sterling money; he knows exactly what he requires to receive or pay in this currency to make his usual profit, and, if the foreigner will remit to or draw upon him a bill in English sterling money, he will cheerfully leave to him any pickings or pleasurable excitement he may obtain from the fluctuations in exchange. As a result an enormous number of bills are drawn on the Continent upon this country, and these form a favourite source of investment among Continental bankers.

Effect of the Bank's Discount Rate. The rate at which they are discounted is the London one, and, should the foreign rate of discount rise above this, it will be to the advantage of the Continental banker to sell or discount his London paper and invest his money at home. If this is done to any great extent the exchange will be forced down, and may in time approach the gold point unfavourable to this country. On the other hand, by raising the rate in this country this danger is averted, and if the excess over the Continental rate is sufficiently great it will in time induce a flow of gold to this country through the lock-up of paper drawn at a currency.

The Bank's directors, therefore, when the reserve is low, the foreign exchanges unfavourable, or the outlook unpromising, prevent by their influence over the money market of this country the export of gold, or even induce its import; while, if the reserve be high, the exchanges favourable and the outlook settled, they will, by the reduction of their rate, assist industry and commerce throughout the country.

Private and Joint-stock Banks. The other banks divide themselves naturally into two distinct classes—the private and the joint-stock banks. The former were at one time a very numerous body, no locality being without its bank, the partners of which were recruited from local families, but of the vast majority no trace is left save a string of names (as an alternative title) on the stationery of the branch of the absorbing joint-stock bank. In not a few instances one family established themselves as bankers in various localities, the style under which the business was carried on varying according to the nomenclature of the local partners.

The London bankers enjoyed a higher standing than their provincial compeers, but even of them only a few now remain. The present day tendency is in the direction of large joint-stock companies possessing numerous branches, some in the agricultural districts, and others in the manufacturing or trading centres, each institution being in this way independent of any outside agencies for deposit or loan business, the total number of bank offices in this country at the close of 1905 being 7,393. No supervision or control is exercised by the Bank of England over its business competitors, although its notes are used by them, and it is made the depository of their reserves. This, however, does not free the Bank from being called upon to assist all and sundry in time of panic.

Branch Banks. A number of branches spread over a large tract of country gives to any bank an increased security—a crisis in any particular part, which would, perhaps, bring about the suspension of a purely local bank, being met by means of the assistance of branches situated in districts unaffected by the movement. The agency of London bill brokers in the employment of the surplus deposits of a bank in an agricultural district in the re-discount of bills held by a bank doing business in a manufacturing county is dispensed with by the amalgamation of the two institutions. The balance between any particular branch and all the other branches (if the amount is due *by* it) shows the excess of its loans and cash balance over deposits—*i.e.*, the excess of assets possessed by the bank at that office. A deposit branch will, on the other hand, be a creditor of the other offices. The nature of the local business transactions have a great effect on the items composing the running account between any branch and the other offices.

The banks in the manufacturing town referred to in the last article will, if the foreign merchants pay in bills on London, receive and remit these for their credit in London. In this way they provide funds to enable the London office or correspondent to meet the cheques on the manufacturing town, issued by the manufacturers in payment of raw material, which cheques will be presented through the Clearing-House by the agents of the bankers of the raw material suppliers. Again, if in the receipts of any office there is contained a greater or lesser amount of cash than it can pay away in the ordinary course of business, the cash balance will be adjusted by periodical remittances to or from another office.

Continued

NORTH & CENTRAL AMERICA

North America—continued. The United States. The Federal Republic of Mexico. The States of Central America. The Panama Canal. The West Indies

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

THE UNITED STATES

New England. New England consists of the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. All belong to the highland region, and rise from a narrow coastal plain to rugged forested highlands, which make lumbering and the allied industries important, especially in Maine. The rivers form falls where they leave the highlands. Along this fall line, at no great distance from the sea, are many manufacturing towns, using cheap water and electric power. Boots, shoes, and textiles are manufactured in the Massachusetts towns; cheap clocks and other Birmingham wares in Connecticut; jewellery in Rhode Island; and boots and shoes in New Hampshire. Fisheries in the coastal waters and on the Newfoundland Banks are important, and much fish is canned or dried for export. Boston (Massachusetts) and Portland (Maine) are the busiest ports and commercial centres. Important universities have been founded, Harvard (Cambridge, near Boston) and Yale (New Haven, Connecticut).

Resources of the Mid-Atlantic States. New York, Pennsylvania, and Maryland lie partly on the Appalachian plateau and partly on the coastal plain, the breadth of which rapidly increases to the south. New Jersey, Delaware, and the district of Columbia, the territory containing the Federal capital of Washington, are on the plain. The Appalachian heights are lowest in the north, where the Hudson and Mohawk valleys, the latter followed by the Erie Canal, make communication across them easy. The Delaware and Potomac make important routes further south, where the height and ruggedness increase.

The forests of the Appalachians supply valuable timber. The Pennsylvania highlands contain immense deposits of coal, iron, and petroleum, making this a wealthy industrial region, with many flourishing towns, of which the greatest is Pittsburg, on the Ohio. Many manufacturing towns—such as Trenton, in New Jersey—have grown up at points where the rivers form falls on leaving the highlands. Lumbering, farming, and dairying are all important, and the fisheries off the coast are of considerable value. Chesapeake Bay has large oyster fisheries, and Baltimore exports both fresh and canned oysters. The whole region is very prosperous, and only a few of the innumerable flourishing towns can be named.

New York, the largest port and commercial and manufacturing centre, has more than half the population of London. It is built on the shores of the Hudson and on islands at its mouth. Among its natural advantages are a magnificent harbour on the Atlantic, and easy communication with the St. Lawrence, the Great Lakes, and the west, by the Hudson and Mohawk valleys. It is the outlet for the whole country east of the Rockies. Built on a relatively limited space, and with an enormous population crowded into a small business quarter, it expands upwards by erecting enormous buildings, or skyscrapers, twenty or thirty storeys high, one building containing the population of a small town. It is a fine city, with broad streets and beautiful parks.

Some Flourishing Cities. The beautiful scenery of the Hudson valley has earned it the name of the American Rhine. Albany, the capital of New York State, is built at the head of tidal navigation. The Mohawk valley and Erie Canal lead to Buffalo, on Lake Erie, which utilises the power supplied by Niagara for its flour mills, distilleries, breweries and machine shops. Troy, near Albany, manufactures shirts. Pittsburg, already mentioned, has oil wells and refineries, as well as the largest steel works in the United States. It was the old Fort Duquesne, and commands many routes to the west, and the important route east across the Appalachians by the Potomac. The outlet of Pennsylvania is the port of Philadelphia, which manufactures locomotives, vessels, and machinery generally. In New Jersey is Trenton, famous for pottery, and Jersey City, in reality a suburb of New York. In Maryland, Baltimore competes with New York and Boston in shipping prairie wheat, which is brought across the Appalachians by the Potomac Gap. Its commerce also includes many products of the southern states and its own manufactures. Washington, the Federal capital, the City of Magnificent Distances, is finely planned on modern lines, with many parks, broad avenues, and national monuments. The Capitol is the meeting-place of Congress, and the White House, the residence of the President, who holds office for four years.

The Southern Atlantic and Gulf States. Virginia, North Carolina, Tennessee, Alabama, and Georgia, belong partly to the Appalachian region, which is here very high, rugged and difficult to penetrate. The forests of the mountains and of a strip of land near the coast are extremely valuable, and timber and turpentine are valuable exports. All the coastal states—Virginia, North and South Carolina, Georgia, Alabama, Mississippi, Louisiana—have hot, moist coastal swamps, in which many valuable crops are grown, chiefly by negro labour. The summers are extremely hot, and the winters warm. Texas, Mississippi, the Carolinas and Georgia lead in cotton, Louisiana in sugar—also cultivated in Florida and Georgia—and in rice,

142. THE UNITED STATES OF AMERICA

also raised in the Carolinas and Georgia. Much of Texas is too dry for agriculture but forms good grazing country. The stock from Texas and from the adjacent Oklahoma and Indian Territory is slaughtered or sent east. Coal is widely distributed in Alabama, Tennessee, Indian Territory, Arkansas and Texas, iron in the first two states, and petroleum in Texas. Steel is manufactured at Birmingham, in Alabama. The cotton manufacture is developing rapidly, especially where water power is available, as at Atlanta and Augusta, in Georgia.

Richmond, in Virginia, at the head of tidal water on the James River, manufactures cotton and tobacco. The Atlantic ports, Norfolk, Wilmington, Charleston, Savannah, and the Gulf ports, Pensacola, Mobile, New Orleans, Galveston, and Houston export cotton. The Atlantic ports also ship lumber and turpentine.

The Prairie States. West of the Appalachians are the prairie states of Michigan, Wisconsin, Minnesota, North and South Dakota, Ohio, West Virginia, Kentucky, Indiana, Illinois, Missouri, Iowa, Kansas, and Nebraska. The north-eastern portion of this area is within the forest belt. Parts of West Virginia and Kentucky are in the forested Appalachian region, but west of these the Black Hills of South Dakota are the only considerable elevations.

These prairie states are the great food-producing regions of the United States. In the eastern prairies wheat is grown in the north, and maize, locally used to fatten hogs, in the south. Stock is kept on the drier ranches of the west. Flour-milling, brewing and distilling, are important in the large towns of the farming regions, and the slaughtering of cattle, the canning and preserving of meat, and the preparation of hides and leather, are important industries in the large towns nearer the ranching districts. The states round the Great Lakes are densely forested, and the lumber industry in all its forms is important. The mineral wealth is great. Much iron is mined round the western end of Lake Superior, and copper is abundant near the south shore in Michigan. Coal is widely distributed, and petroleum and natural gas abound in Ohio and Indiana. Gold is obtained in considerable quantities in the Black Hills of Dakota. Many industries are growing rapidly, the principal, in addition to those connected with food-stuffs, being the manufacture of railway plant, for which both iron and timber are easily obtained. Shipbuilding is important at many of the lake ports. Add to this the very great facilities for movement in all directions across the level prairies, and the admirable water communication by lakes and rivers, and the actual and potential riches of these states become evident.

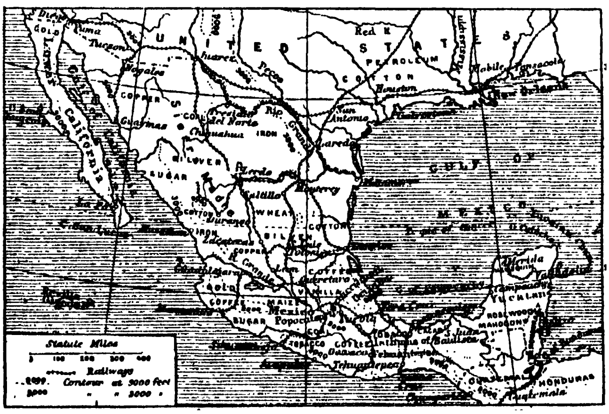
Cities of the Prairie States. The capital of the prairies is Chicago, on Lake Michigan, built on the site of an old fort from which there was an easy portage to the Illinois tributary of the Mississippi. This is now followed by a canal, which permits through water communication between the Gulf of St. Lawrence and the Gulf of Mexico. Chicago is one of the greatest railway centres in the world, and the half-way house at which the products of east and west are exchanged. It has important manufactures of iron and finished lumber, but its characteristic industry is the slaughtering and preserving of the cattle and hogs fattened further west. Other important meat centres are Kansas City, Omaha, and Indianapolis. Cincinnati, once nicknamed Porkopolis, no longer deserves the name. Population has moved west, and Cincinnati, formerly on the western margin of the settled area, is now too far east to be a meat market of the first rank. Its situation makes it an important commercial and transport centre. The leading state in lumber is Wisconsin. Minnesota takes the lead in flour-milling. The greatest flour-milling town is Minneapolis, at the Falls of St. Anthony, which supply the necessary power. It is practically continuous with St. Paul, the head of unbroken navigation on the Mississippi. Duluth and the lake ports ship much wheat. Brewing and distilling are important at Milwaukee, on Lake Michigan, at Louisville (Kentucky)—famous also for its tobacco market—built where rapids interrupt the navigation of the Ohio, and at many other advantageously situated towns. Cleveland (Ohio) has large ironworks, and is the port from which much Lake Superior iron ore is sent to Pittsburg. Of route towns note the importance of St. Louis, at the confluence of the Missouri and Mississippi, where many routes by land and water converge. These are but a few of the conspicuously prosperous cities in a region which little more than half a century ago was almost untrodden by white men.

The Mountain States. Little need be said of the mountain states of Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, and New Mexico. They are large, infertile, and thinly populated. Lying in the lee of lofty mountains, their climate is very dry. Most of the drainage is to the Pacific or the Gulf of Mexico, but in Utah and Nevada there is a great area of inland drainage, the Great Basin. The little rain that falls evaporates very quickly, and the rivers flow to lakes whose level is not high enough to allow an outlet to the sea. South-western Arizona and Eastern California form the American desert. The natural resources are much less valuable than in the prairie states. The mountains contain great mineral wealth, including gold and silver; but mining alone never leads to the permanent development of a region. Unless other sources of wealth are there, prosperity vanishes when the richer mines are worked out. These states have few such permanent resources. Ranching is successful in the eastern parts of Montana, Wyoming, and Colorado, but the risk of losing stock through want of water makes it more precarious than in the prairie states. Agriculture is possible with irrigation. In the future great engineering works for irrigation will doubtless be undertaken. Salt Lake City, in Utah, illustrates the prosperity which results from successful irrigation; and this prosperity is spreading to the irrigated regions at the eastern base of the Rockies.

Towns are not yet numerous. Denver (Colorado) has smelting works and other industries. Cheyenne (Wyoming) is the centre of the ranching country, and an important railway centre. Natural beauty and bracing air are assets which will become valuable. Colorado Springs is already a frequented health resort.

The Pacific States. The Pacific states, Washington, Oregon, and California are wooded in the west but arid in the east. Lumbering is important. Much of the timber used in the woodless districts of China comes from Puget Sound. Much wheat is grown in the fertile valleys between the coastal ranges, and the mountains further east. The valley of Southern California, with the climate of Italy, produces all fruits in perfection, and manufactures wine. The salmon fishery is important in many rivers.

The chief town is San Francisco, with a fine harbour of great natural beauty and railway communication with all parts of the continent. It is the New York of the Pacific, and the starting-point of the trans-Pacific lines. Seattle and Tacoma (both in Washington) and Portland (Oregon) are important ports further north and terminal stations of transcontinental lines. Of inland towns the most important is Sacramento, in the Californian valley.



143. MEXICO

Alaska. Alaska is on the margin of tundra and forest, and belongs to both regions. Gold is abundant in the sands of the Yukon and its tributaries and on the seashore near Nome. St. Michaels is the port of the Yukon. From Dyea the railway is carried to the upper Yukon, in Canada.

MEXICO

South of the United States lies Mexico, a federal republic of many states and territories, under an elective president.

Mexico is a continuation of the southern United States, which it resembles. It lies between the Atlantic and Pacific Oceans, and includes the southern part of the Californian peninsula in the north-west, and the low peninsula of Yucatan in the south-east.

Mountains and Rivers. The two oceans are bordered by mountain ranges, between which is enclosed the plateau of Central Mexico, a continuation of the Colorado plateau. This plateau rises in height from about 3,000 ft. in the north, to 8,000 ft. in the Anahuac plateau, on which is the capital, Mexico City, in the south. Many ranges cross the plateau, and in the extreme south is a lofty chain of volcanoes, active, dormant, and extinct. Orizaba (18,500 ft.) is one of the highest points of the continent.

South of the Rio Grande, which forms the Texan frontier, the rivers are impetuous mountain torrents, or flow in deep, rocky gorges, or *barrancas*, which may be 1,000 ft. deep. These barrancas are often dry, except after rains, but they make communication across the plateau difficult.

The Pacific coastal plain is narrow. The Atlantic coastal plain is about 60 miles broad and fringed with lagoons. Mexico has very few good natural harbours in a coast-line of 6,000 miles.

Climate. Three zones of climate are distinguished by the Mexicans. Up to 3,000 ft. is the *tierra caliente*, or hot belt, with a tropical climate; from 3,000 to 9,000 ft. the *tierra templada*, or temperate belt; and above 9,000 ft. the *tierra fria*, or cold belt. Within these belts there is naturally considerable variation, according to elevation.

Northern Mexico and the Californian peninsula resemble the adjoining arid regions of the United States, and only the mountains receive rain. There is a desert area in the lee of the western Sierra Madre. Elsewhere, there is more or less rain during the summer wet season, but the dry season is rainless.

The *tierra caliente* is covered with tropical forest, producing palms, rubber, and the valuable rosewood and mahogany. In the *tierra templada* the plateau is treeless, but the mountain slopes are forested with evergreen oaks and, higher, with the usual temperate forest trees. In the drier regions the vegetation is of the desert type. Giant cacti are common, and the agave, or American aloe, from which a highly intoxicating drink and a most useful fibre are obtained, is very abundant.

One of the most forbidding varieties of cactus grows to from 5 to 15 ft. high, the whipstock arms being without branch or joint but covered close with heavy, recurved thorns, like tigers' claws. Then there is the tree yucca, big of trunk and branched like an oak, and bearing on the end of each arm a bunch of bayonet-shaped leaves, the dead stems of which form the bark, and so dry that when lighted the whole flames up. Or, again, there is the pita haya, mightiest of cacti, which, as single stems or branches, look like green telegraph poles or giant candelabra.

Mexican Scenery. With its combination of forest and desert, plateau, mountain and barranca, the scenery of Mexico is very varied. A traveller in the north-western Sierra Madre writes: "One may traverse a group of high, dome-topped hills, beautifully studded with dwarf pines or mountain oak, and clothed with long grass, the home of the antelope and the turkey, and in another mile these may be suddenly cut off by some huge chasm, surrounded by towering crags and steep, water-worn gullies. Then may follow a glimpse of the main ridge, crowned with its pine and cypress forests, and perhaps streaked with snow. At high altitudes, throughout this range, occur the charming level plots called llanos, and known in the Rockies as parks. These are frequently seen at a parting of the waters, where an infant stream creeps through the deep, alluvial soil, and nourishes the meadow-like expanse surrounding it. Groups of stately trees are dotted over these tracts. Within an hour or two of mule riding all this may have given place to a series of precipitous heights, wild, ragged, and nearly bare, except of cactus and mosquito."

Agriculture and Minerals. With water, the soil of Mexico is fertile, and where irrigation is possible, two crops a year can be grown. The agricultural methods, as might be expected in a tropical country, where four-fifths of the people are wholly or partly of Indian blood, are very primitive. In recent years, much attention has been given to better methods on the larger farms or *haciendas.* In the coastal belt it is almost impossible for white men to do heavy work. Coffee is the most profitable of the crops of the tierra caliente, which also produces sugar, cacao, cotton, and vanilla. The dry climate of Yucatan suits fibre plants, the most valuable of which is henequen, or sisal hemp. On the plateau, wheat is grown wherever irrigation is possible; the vine does well in many districts, and maize and tobacco are cultivated in the Anahuac plateau. An immense variety of fruits, tropical and temperate, come to perfection. Mexico is enormously rich in minerals. Its 1,300 silver mines turn out many millions pounds' worth of silver annually. Gold is also worked, as well as iron, copper, and tin. There are deposits of coal and petroleum, but, owing to their situation, it is doubtful whether they can be profitably worked, and many locomotives have to use wood fuel.

Economic Conditions. There are some manufactures, including textiles, pottery, straw hats, etc., but the great resources of Mexico will probably always be agriculture and mining. Mexico has several natural disadvantages. The better watered and more thickly peopled southern plateau lies 8,000 ft. above the sea, communication with which is therefore difficult and costly. Till 1873, when the line from Mexico to Vera Cruz was opened, there was no railway from the coast to the plateau. Mexico is now connected by several routes with the lines of the United States, but even on the plateau the numerous mountains and barrancas make the construction of railways difficult and costly. There are no navigable rivers except in the Atlantic coastal plain, which is unsuitable for white settlement. These causes, and the preponderance of Indian over European blood, made Mexico develop more slowly than its great neighbour.

Towns. Mexico City, finely situated in a plain 8,000 ft. above the sea, dominated by the great volcanoes of Popocatepetl and Ixtaccihuatl, carries on various manufactures. The ports on the Atlantic are Tampico and Vera Cruz, and on the Pacific the Acapulco, one of the finest harbours in the world, and Mazatlan, all connected with the plateau by rail. A railway crosses the Isthmus at Tehuantepec.

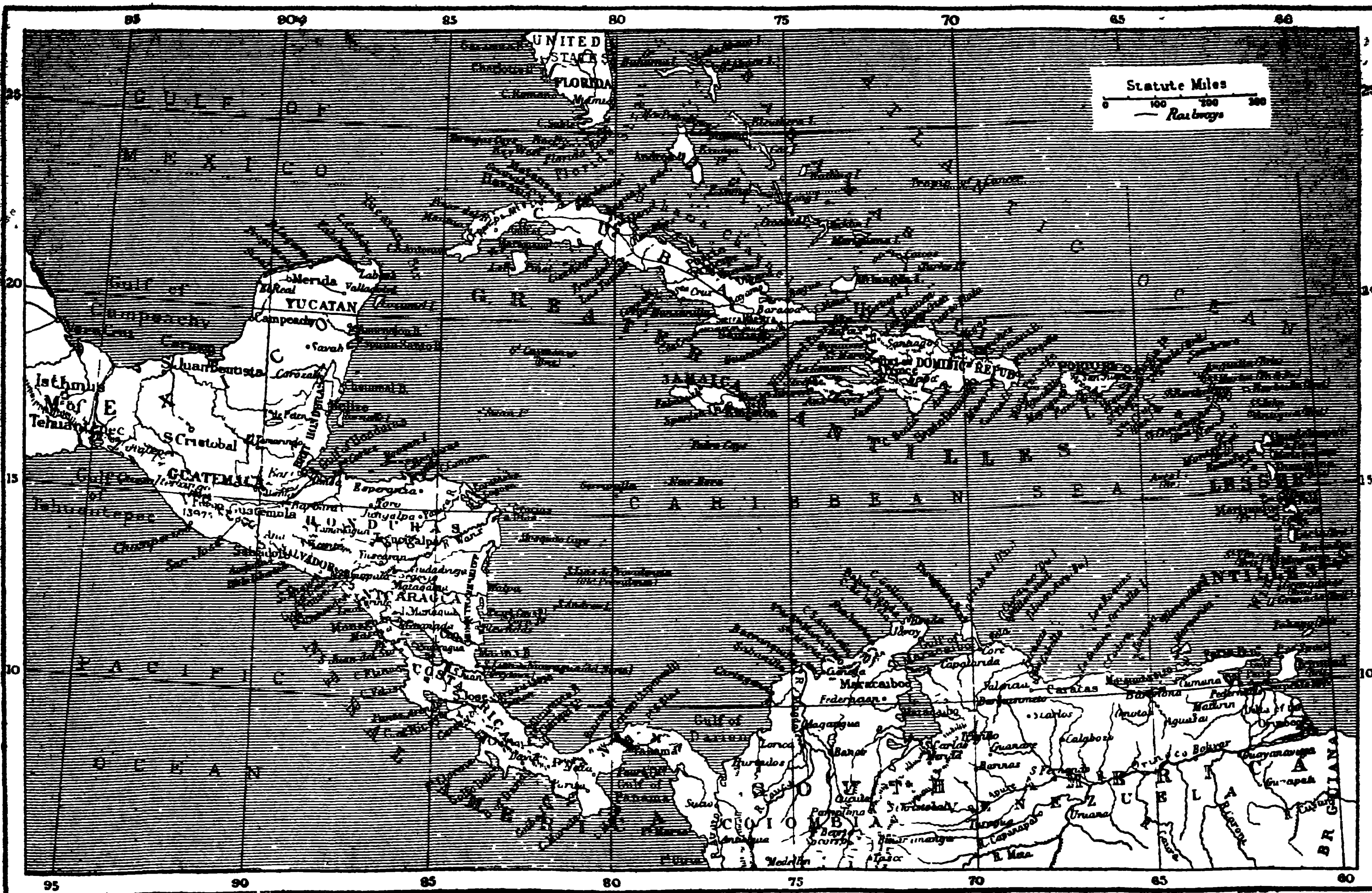
CENTRAL AMERICA

Central America is united to North America by the Isthmus of Tehuantepec (130 miles broad, 390 ft. high), and to South America by the Isthmus of Panama (31 miles broad and 285 ft. high). Its length of 1,200 miles is occupied by the southern part of Mexico, British Honduras (7,500 sq. miles), and the republics of Guatemala (42,500 sq. miles), Salvador (8,000 sq. miles), Honduras (46,000 sq. miles), Nicaragua (48,000 sq. miles), Costa Rica (21,000 sq. miles), and Panama, all with few white inhabitants.

Climate and Products. Central America is mountainous and volcanic, with one important depression, occupied by Fonseca Bay, Lakes Managua and Nicaragua, and the San Juan river. Here it has been proposed to unite the Pacific and Atlantic oceans by cutting a canal. Among the difficulties attending the enterprise is the existence of an active volcano on an island in Lake Nicaragua. The coastal plains are narrow, forested, and often swampy. The same zones of climate and vegetation—tierra caliente, tierra templada, and tierra fria—are found as in Mexico. The rainfall is everywhere heavy. The forests of the tierra caliente supply rubber, mahogany, logwood, bananas, coco-nut palms, drugs, and other produce. The cultivated crops include cacao, cotton and coffee—that of Costa Rica being specially good; and cotton, tobacco, maize, wheat, potatoes, etc., are grown at suitable elevations in the tierra templada, much of which is forested. The west is the better cultivated and more populous side.

Towns. Belize, in British Honduras, ships mahogany, logwood, rubber, coco-nuts and bananas. In Guatemala a railway runs from the Pacific port San José to the capital, Guatemala City, and thence across difficult country to the Atlantic port Puerto Barrios. The coffee, sugar, vanilla, and indigo of Salvador are shipped from La Libertad, the port of the capital of San Salvador. Honduras contains no towns of importance. In Nicaragua a railway runs by Leon, Managua, on Lake Managua, and Granada, on Lake Nicaragua, to the chief port, Corinto, on the Pacific Coast. Another line crosses Costa Rica from the Atlantic through San José, the capital, to Punta Arenas on the Pacific.

A railway 45 miles long is constructed across the narrow Isthmus of Panama from Colon or Aspinwall on the Atlantic to Panama on the Pacific. A great ship canal is in course of construction.



144. CENTRAL AMERICA AND THE WEST INDIES

THE WEST INDIES

The West Indies lie between North and South America. Off the coast of Florida are the low, infertile coral Bahamas, belonging to Britain and producing chiefly sisal hemp. The Greater Antilles are Cuba (45,000 sq. miles), Jamaica (4,200 sq. miles), Hispaniola (10,000 sq. miles), and Porto Rico (3,700 sq. miles). The numerous Lesser Antilles are all small. Off the mouth of the Orinoco are the British islands of Tobago and Trinidad (1,870 sq. miles).

Climate and Products. All the West Indies are tropical, though most are high enough to have a temperate climate and products in the highlands. Late summer and autumn is the rainy season, and the heaviest rainfall is on the east. Destructive hurricanes often cause immense loss of life and property, while disastrous earthquakes and volcanic eruptions occur from time to time. In 1902 the eruption of Mont Pelé, in Martinique, one of the Lesser Antilles, destroyed the town of St. Pierre and nearly 30,000 inhabitants.

The soil is very fertile, especially in the volcanic islands, and all kinds of tropical produce can be raised. Most of the islands are covered with dense forests, producing mahogany, and other valuable timber. The once flourishing sugar industry is declining, except in Cuba, through neglect of modern methods of cultivation and also owing to the competition of bounty-fed European beet sugar.

Beauty of the West Indian Scenery. Every traveller vainly tries to paint the beauty of a scene made up of mountains, forest, and sea. "The mountains range higher and higher," writes Kingsley of Guadeloupe, in the Lesser Antilles, "with corries and glens, which, when seen near, must be hanging gardens of stupendous size. Tiny knots on distant clifftops are really single trees of enormous height and breadth. Gullies, hundreds of feet in depth, represent the rush of the torrents which have helped through thousands of rainy seasons to scoop them out. In singular contrast with the rugged outline is the richness of the verdure. Each glen has buried its streamlet a hundred feet deep in vegetation, above which here and there towers the grey stem and dark crown of some palm. The islands, though intensely green, are not of one, but of every conceivable green, or, rather, of hues ranging from pale yellow through all greens into cobalt blue. As the wind stirs the leaves and sweeps the lights and shadows over hill and glen, all is iridescent, like a peacock's neck, till the whole island, from peak to shore, seems some glorious jewel—an emerald with tints of sapphire and topaz, hanging between blue sea and white surf."

Tropical Fruits. The fruits of Cuba show the profusion of Nature's gifts in the tropics. Besides the well-known banana, orange, lemon, lime, and fig, are many fruits unfamiliar to us. "The rose-apple, or rose-fruit, is as large as a good-sized peach, smooth-skinned and cream-coloured, with an odour and taste of attar of roses. The mango grows on a tree very similar to our apple-tree. It is the size of a pullet's egg, yellow in colour, grows in long bunches, and is very juicy when fully ripe. The sapotilla is a fine tree, with a bell-shaped white flower, as fragrant as apple blossoms. The delicious fruit is the size of a peach, in a rough russet skin. The custard apple grows wild, and is also cultivated. It is green in colour, tough-skinned, acid in flavour, and full of small black seeds. The star apple is so-called because when cut in half a star appears in the centre. The meat is green in colour, is eaten out of the skin with a spoon, and tastes like strawberries and cream. The guava, though not eaten in its natural state, is of universal use in making the well-known guava preserves and jelly. It has a peculiar odour, which will scent a room for hours. The tamarind grows in a pod-shape on a lofty shade tree, and when ripe is of the consistency of marmalade and quite as luscious. The alligator pear is used as a salad. Last, but not least, is the pineapple. The fruit grows out of a bunch of great leaves 18 in. or 2 ft. from the ground."

The Greater Antilles. Cuba is an independent republic, though with intimate relations with the United States. It is the largest of the islands, and is mountainous in the west, where the tobacco from which the famous Havana cigars are made is grown on the lower slopes of the Organos Mountains. Sugar is grown in the hilly centre. The eastern mountains are rich in iron The rich forests contain many valuable trees, including the royal palm, mahogany, and the Cuban cedar, of which cigar boxes are made. Havana, the capital, is on the north coast.

Jamaica, the largest British island, rises to over 7,000 ft. in the eastern Blue Mountains. Many rivers water its fertile valleys. Bananas have replaced sugar as the chief export. Coffee, cinchona, allspice, ginger, arrowroot, tobacco and cacao are also cultivated in the clearings of the forest, which covers most of the island. The capital is Kingston.

Hispaniola consists of the black republics Haïti (capital, Port au Prince) and San Domingo (capital, Santo Domingo). It has the usual West Indian resources, but these are little developed.

Porto Rico, a possession of the United States, is very mountainous. Cattle are kept on the higher grass lands, while the plains and valleys produce the usual West Indian crops. The capital is San Juan.

The Lesser Antilles. The largest islands —Guadeloupe (580 sq. miles) and Martinique (380 sq. miles)—are French. Both are volcanic. The usual crops are raised. The islands forming the Leeward and Windward groups are British. On Santa Lucia is Castries, formerly a British naval station, the best harbour in the West Indies. Barbados has a dense negro population, engaged in cultivating sugar. The Dutch and Danish islands are of no great importance.

Trinidad and Tobago. Sugar and cacao are the chief products of Trinidad and Tobago. The Pitch Lake of Trinidad supplies large quantities of asphalt, brought down to Port of Spain, the chief town.

Continued

HARMONIUM PRACTICE

Reading at Sight. The Registers. Stop Combination Effects. Choice of Secular and Church Music. Practice Hours

By J. CUTHBERT HADDEN

IN the matter of reading music, the study of harmony helps to a wonderful extent. The frequent appearance of certain chords leads to such an intimate acquaintance with these chords that the player by-and-by, recognising them at once as a whole, is saved the trouble of "spelling out" to himself their individual constituents. Before beginning to play an unfamiliar piece, it is necessary to make yourself familiar with the key and the time. If the key is a difficult one, impress on your memory its third and seventh notes, especially; play, too, once or twice the scale formed upon that key, and its relative minor. Then it is well, before starting, to look over the piece from beginning to end, as very probably the first page presents no difficulties, while the second may unexpectedly present something of a very startling nature. One of Schumann's maxims to young musicians is: "Should anyone place a composition before you to play for the first time, look it through previously." This advice should certainly be followed. In reading at sight, it is useless to stop when a mistake has been made. If you do this, and return to the passage, you are *practising*, not reading the piece.

To gain confidence in playing at sight it is well at first to take some simple piece for reading—simple not only as to technical execution, but simple as to key. The practice should be regularly kept up, and as great a variety of material as possible chosen. "Playing at sight," says Ernest Pauer, "is a kind of economic musical knowledge, and the following conditions are necessary for it: (1) a good grounding in technical execution; (2) a regular and systematic knowledge of fingering; (3) a cheerful and ready disposition; and (4) undivided attention and concentration of the mind on the work in hand." Some of these remarks are, of course, much beyond our present stage, but many of them will be of help now, and all can be recalled as the student advances.

Four-part Playing. We return now to the "Harmony Player," and begin the work of the third step with four-part music and four new keys. In previous exercises the compass of the hand has been within a fifth. But this has been only a concession to the learner; music cannot be confined within such a restricted limit. The compass must now be widened, and that involves certain extensions of the thumb and fingers in order to reach the outer notes.

Look at Ex. 37. You will see that the right-hand part ranges from B to G—a sixth. Now, were it not for the B, which occurs four times in the alto, the whole might be played with the fingers in their first positions. As it is, we must give two notes to the thumb, using it for its own proper digital (C), making it shift down to B when that note occurs, and back again to C. In the left-hand part the compass is also a sixth, and the thumb is treated in the same way as in the right hand by making it move upwards to A in the last bar and down again to G. This shifting of the thumb will be found constantly necessary in the inner parts, and the student should learn to manage it as neatly as possible so that the break in the sound may be all but imperceptible.

A short prelude is the form in which the next exercise is presented. It is very simple until we reach the third bar, where, in two chords, the right hand has three notes instead of the usual two. The upper parts of this and the following bars should be practised thoroughly by themselves before combining with the under.

The fingering from the beginning of the penultimate bar to the end will be:

|	1	3	2	| 3	2
|	2	1	×	| 1	×
|	×	×		|	

Notice to keep the first finger on the tenor A in the last bar of the left-hand part when the fourth finger takes the bass D. The tendency will be to shift the thumb on to it, but there is no necessity for this.

Practice in the Key of A. Ex. 39 brings forward the key of A with three black digitals. It is not difficult in itself, but may require considerable practice on account of the strange key. In the left hand we are obliged to break our rule regarding the use of the thumb on a black key. There is no other way—keeping them in the left hand—of playing the C sharps which occur in the tenor but by shifting the thumb upwards from B. The C♮ intervening makes this uncomfortable at first, and the fingering in early attempts may be far from smooth. But the difficulty can readily be mastered by practising the left hand by itself slowly.

In Ex. 40 we reach the practical limit of sharp keys with the key of E, employing four black digitals. In the right hand the × will have to shift from E to D♯, and in the left (sixth bar) to move upwards to C♯. Space need not be taken up in speaking in detail of Exs. 44–50. Though introducing the stretch of an octave, they will prove of no difficulty if the preceding exercises have been mastered.

A word may, however, be said about a definite left-hand fingering for the cadential form of the dominant seventh chord as seen in the last bars of Exs. 44 and 45. Take Ex. 44 as example. Ordinary hands would usually play the B♭ and A of the tenor as at (*a*); in the case of those having longer fingers, it would be most convenient to play these notes as at (*b*):

(*a*) (*b*)

This is such a common progression that the student should decide at once which of the fingerings he will adopt, and stick to it.

Ex. 51 brings the key of A♭, with four black digitals. It is simple until we reach the last cadence. Here the thumb cannot play both G and E♭ in the alto, but by a little stretch the G may be taken by the first finger. The thumb of the left hand has a good deal of shifting to do, having to play in all four different notes—E♭, D♭, C and B♭. A short chant in G follows, where we have the peculiarity of three parts in the right hand almost throughout. This, again, involves a good deal of thumb shifting in the inner part, the fingers being left free as much as possible to play the treble smoothly. The right hand fingering should be:

4	4	3	4	—	2	1	4	4	3	1	
1	1	1	1	—	×	×	×	1	1	1	
×	×	×	×					×	×	×	

In Ex. 42 you will observe that a scale passage is completed between alto and bass. Keep the E firmly down, and do not be alarmed at the dissonance produced by the entry of the D in the left hand. The last chord in the next exercise has three of its parts in the left hand. Keep the fourth finger on the continued E, take the B with first finger, and the D with thumb, shifting the latter on to the C♯ in the last chord. Ex. 43 might have come sooner, for it introduces the key of E flat, with only three black digitals.

In the right hand the compass is a seventh. A♭ being the highest note, we play it with the fourth finger, and this, giving the tonic to the first finger, necessitates the thumb taking both B♭ and D. An exception will be found in the penultimate bar, where we are obliged to stretch the first finger down to D, the thumb being already occupied with the B♭ held on in the alto. In the left hand the thumb has to play three notes—A♭, G and F. The remaining exercises in this step are all in keys already learnt, and involve no special difficulties. The last, however, Ex. 53, gives directions for the use of certain stops, which suggests that we had better turn aside for a little now, and try to learn something of the tone character of the different registers.

Use of the Registers. This is, indeed, very essential. The full resources of a good instrument can be brought out only by a player who knows what are the special individual qualities of the "knobs" at his command—how and when to use them, singly and in combination. Nothing produces a worse effect than the indiscriminate use of the various registers, and nothing is more common with amateur players. Of course, as Mr. King Hall observes, since no two harmoniums are precisely alike in *timbre*, it is impossible to draw up a table setting forth accurately the qualities of the registers individually; but the following remarks can be taken as approximately correct. Taking, then, the stops of our original instrument of four sets of vibrators in pairs, treble and bass, we have:

1. Flute; 1. Cor Anglais. This is one of the most useful stops in the instrument, suitable alike for slow or quick music, and may be effectively combined with any of the other stops. Its tone is of a round and fluty character, comparatively full, and with the advantage over some of the others of promptness of speech. It corresponds with the diapasons of the pipe organ, and should be used for all music of a soft nature.

2. Clarionet; 2. Bourdon. This stop somewhat resembles 1 in being of a round and fluty quality, but the tone is much broader and heavier, and the response to the touch is slower. When you draw it, you will observe that it produces sounds an octave lower than the actual note played. Hence, if you were to use this stop alone it would be necessary to play the music an octave higher than written. But, as a matter of fact, 2 is seldom used alone except in the treble for solo work, as we shall see presently.

3. Fife; 3. Clarion. This stop produces sounds an octave higher than written. It is of a bright and reedy character, prompt in speech, and adds brilliancy when combined with the other stops. It should rarely be employed alone, except for echo effects in secular music, and in some other cases. The tone, in spite of its brightness, is so slight that when used with either of the stops which sound the notes as written, the higher octave is scarcely heard, being absorbed in the greater volume of the standard pitch registers. The student must not confuse "Clarion" with "Clarionet."

4. Oboe; 4. Bassoon. This stop is supposed to imitate the tone of the instruments after which it is named. The tone of the *Oboe* especially is thin and reedy, of a softer quality than the *Flute*, but of the same standard pitch. It is rather slow of speech, but may be used very effectively for music of a pastoral nature, and can be drawn instead of 1 when a quieter effect is desired. The *Oboe* is also used for

solos, and, combined with the *Flute*, makes a fair imitation of the voice, as here:

Among the stops in larger instruments will be found: 5. MUSETTE and 6. VOIX CELESTE, both on the right-hand side. The first is a soft, reedy stop, more delicate than the *Oboe;* the second is generally joined to some other stop, and by tuning its reeds a little sharper than those of the latter, a clear, ringing, vibrating effect is produced. The *Voix Celeste* may be used for solo work, either alone or with the *Clarionet*, but should not be used with all the other stops.

Effects from Combinations of Stops. The possible effects which can be produced out of only eight sounding stops are almost endless in their variety. One or two suggestions may be offered. For ordinary four-part playing a very serviceable and effective combination is 1 and 4 for both hands. Also 1 and 2, which, with the music played an octave higher than written, will be found useful for most compositions of a serious cast. Stops 2 and 3 and 1 and 3 are a sort of "fancy combinations," as Mr. King Hall calls them: the first for sacred music, the second for music of a light, bright nature. In many instruments a couple of ordinary pitch registers are perfectly able to assert themselves against one lower octave stop; and when this is the case there is no need to play the music an octave higher than written. But the greatest advantage to be gained by 2, with the right hand transposed an octave higher, is that a solo may be played (with a soft left-hand accompaniment) without any risk of going below F—the dividing place of the stops—and finding the melody disappear.

Solo Passages. In order to give prominence to a solo a louder tone must be used in the right hand than in the left, and it follows that unless 2 is used in the manner mentioned the solo will suffer should its range take the player into the bass part of the instrument. Of course, where the solo does not go below F, any loud combination may be used with as soft an accompaniment in the left hand as can be obtained from the particular instrument in use. Generally speaking, the *Sourdine* offers the softest accompaniment for a solo melody with a single stop; but sometimes it is so strong that the right hand must be played with 1, 4, or with *Celeste*, or with 1 and 2, an octave higher.

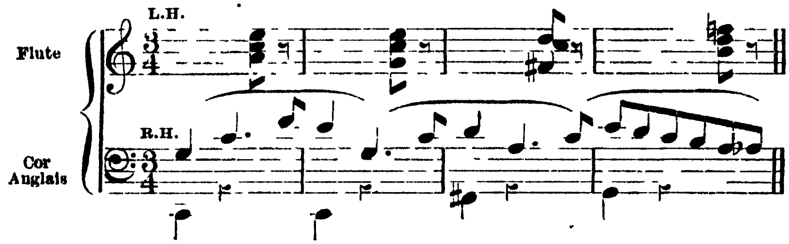
An effective manipulation of the stops is as essential to the harmoniumist as to the church organist. Without it, his instrument is reduced to the level of a dead monotone, as it were; with it, the instrument becomes instinct with life, capable of giving expression to all the varying shades of emotional feeling which musical composition may inspire. Of course it is necessary that one should play fairly well before making a special study of the tone colours rendered available by the various stops. Tone colour is of very little use in merely elementary work, where the player is very much occupied with other things. But as soon as he feels that he has gained a certain facility in the use of the keyboard, he ought to devote a considerable amount of time to the special study of the stops.

With regard to effects of what may not inaptly be called a secular character, it is difficult to make a selection. The following are offered merely as hints which the student can readily adapt and improve upon according to the resources at his command. A charming orchestral effect is produced by combining *Clarionet* and *Flute* in melodies requiring to be doubled, as in the following from *Le Prophète*:

The *Clarionet* stop may also be used alone with good effect in baritone solos, as in this example:

The value of the *Clarion* stop, again, may be tested by such an example as the following:

Even with only *Flute* and *Cor Anglais*, such an excellent effect as we have here may be produced:

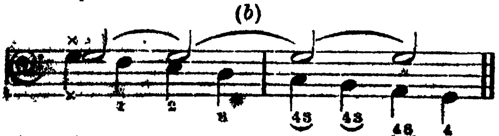


These, as we have said, are only hints. If the student will but test them carefully for himself, he will feel competent to make further successful experiments on his own account. Experience, assuming his own good taste, will reveal to him many charming combinations which he will readily find a means of adopting as his repertoire increases.

Finger Releasing. With the fourth step of the "Harmony Player" we arrive for the first time at the system of fingering peculiar to the harmonium and the organ. This is the system known as *finger releasing*. Hitherto the student has been able to play the outer parts (the treble and bass) of all his exercises without any jumping of the fingers. In the inner part the thumb has been allowed (necessarily) to shift or jump from one key to another—a method which can never be allowed for the outer parts (unless when marked *staccato*, of course), because these being specially prominent, the slightest break in the continuity of the sound is immediately noticed. In short, on the harmonium we must have *legato* fingering. We cannot, for example, play the following as at (*a*), which would pass on the piano; we must play it as at (*b*), releasing the fourth finger always in time to provide a finger for the next note:

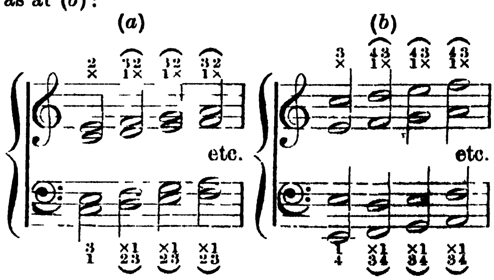
(*a*)

(*b*)

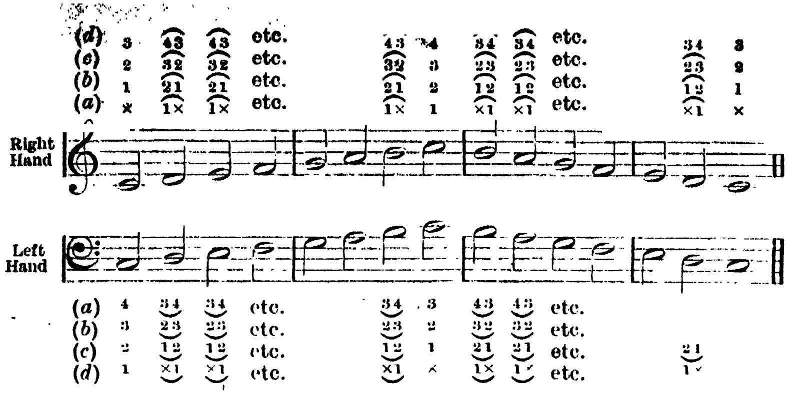


This is a method of fingering which will be found more or less, as the need for it arises, in all the exercises remaining* to be studied. The learner whom we have been guiding thus far must now begin to practise it systematically; and it is at this point that the student who already plays the piano may begin. What *he* has to learn first of all is emphatically the legato fingering. Many useful exercises for giving facility in this direction are included in both Mr. King Hall's "Harmonium," and Stainer's American Organ Tutor. The student will probably find it best to take first the simple scale C, and play it up and down, releasing all the available fingers in turn. [See next page.]

Practise this very carefully before going further, each hand separately, and with the lines of fingering in their alphabetical order, as marked. Be sure that a perfect *legato* is obtained, that the key is held firmly down while the finger is being released. The professional student would be required to carry the exercise through all the scales in order to gain the necessary facility in relieving the fingers upon the black keys. The amateur may, for the present, content himself with the above, having mastered which, he may go on to practise double notes with finger releasing; first thirds, as at (*a*), and next sixths, as at (*b*):



These exercises, and others which will be found in King Hall and Stainer, are indispensable to the cultivation of the true *legato*, the charm of the harmonium as of the organ. The student who already plays the piano should work through them all at once; our learner who has been going through the "Harmony Player" may, after having accustomed his fingers to the releasing style by the scale, and two exercises as illustrated above, proceed with the four-part and other exercises from No. 55 on to the end of the book. He will then acquire a thorough command of the style necessary for the playing of psalm and hymn tunes, chants, etc. For this special



purpose the eight pages of chants and hymn tunes printed in Stainer's tutor might also be gone through with advantage, particularly as various methods are there shown of playing this class of music, with the usual two parts in each hand, with the melody in octaves, with the melody on a solo stop, and with the bass in octaves.

Pieces. The student who desires to play pieces chiefly will probably not wish to give so much time to church music. In that case he may start at once with the "Thirteen Original Pieces" of Mr. King Hall; or, if he feels that he is not quite advanced enough for these, let him work up the Stainer exercises in two, three, and four parts. These are fully fingered, and represent styles quite different from the psalm or hymn tune; though marked for the American organ, they are equally well adapted to the harmonium.

In playing pieces where there is a single part in either hand, especially if the music moves at all quickly, it is usual to employ what is known as scale fingering, the turning of the thumb under the fingers, or the fingers over the thumb. Thus, if the following scale passage occurred, it would be fingered, for the right hand as above the stave, for the left hand as below:

In a case of this kind there is no need for finger-releasing, of which, indeed, the time does not permit. The learner whose ambition is to play pieces chiefly would thus do well to go through a complete course of scale exercises in all the major and minor keys in common use. Such a course will not only add to his facility in fingering; it will add to his reading power, and give suppleness and dexterity to the hands besides.

The rules for fingering the scale are simple in principle, though they require at first great attention. In the ascending right hand, the thumb is placed on the first white key which occurs, and afterwards follows the second and third fingers alternately. In descending, each note is played with the same finger as in ascending, and the same rule is followed, but in reversed order, the third and second fingers passing alternately over the thumb. In the left hand the fingering of the ascending scale follows the rule of the descending scale in the right, and *vice versâ*. A printed set of scales with the fingering marked can be obtained from any music-seller. If the student has a piano, they may be practised chiefly—not solely—on that instrument.

General Hints on Fingering. In regard to the whole subject of fingering, it may be remarked that facility cannot be forced; it must be allowed to come in its own time. With experienced players fingering is a sort of second nature; they "never think about it"; the fingers seem to work like automatons, adapting themselves in some mysterious way, almost mechanically, to the music being played. Let it be said, too, that whatever method of fingering secures to the individual player the smoothest result, and affords the greatest convenience, *that* is the fingering for him. The finest players occasionally differ as to their fingering, and allowance must always be made for the construction and size of the hand. One of the greatest secrets of good fingering is the habit of looking forward to the coming phrase, seeing, if even vaguely at first, what has to be done, and so preparing the fingers as to secure the best rendering of the passage. In any case, there must be no slovenly, "anyhow" fingering. The person who fingers badly or carelessly can never be a really good and satisfactory player.

Selection of Pieces. After you have finished with your tutors and are able to play fairly well, you will naturally desire to work up a repertoire of pieces. If you are contemplating church playing, then, of course, sacred music—collections of voluntaries, etc. —is what you will direct your first attention to. There is plenty of music of this kind, and we can mention here only such collections as we think to be educationally as well as practically most useful to the student. For those who have mastered the exercises in the "Harmony Player," the best selections of pieces to follow that work are Volumes VIII. and XII. of the "Harmonium Album" (Curwen). These are fingered throughout, and are very suitable for beginners. The "Harmonium Album" extends altogether to 15 volumes. The first 14 comprise some 500 voluntaries, while the fifteenth is chiefly made up of movements from popular operas. The same publishers have also a collection of interesting "Harmonium Studies," by J. Frank Proudman, and a couple of volumes of musicianly "Sketches for Harmonium," by John Kinross. The best work to succeed Mr. King Hall's primer

is the same author's "Original Studies and Arrangements for the Harmonium or American Organ." The studies are peculiarly valuable, and the editor's directions as to their rendering are sufficiently clear.

Voluntaries. Collections of "voluntaries," expressly so-called, are numerous. One of the best is that of Mr. J. W. Elliott (Novello), in two volumes, containing altogether about 350 pieces. Collections of original harmonium voluntaries by Oliver King and Max Oesten, issued by the same publishers, may also be recommended. It is better that the young church player should draw upon such works as these until he has gained experience enough to make arrangements for himself. For general use there is nothing better than the two volumes of "The Harmonium Treasury" (Novello), in which we have a series of select pieces, secular as well as sacred, admirably arranged for the instrument. Chappell's "Harmonium Journal," full music size, will also be found useful, as including rather more secular-music arrangements. All these works can be adapted to the American organ. Of collections specially made for that instrument, there is no need to mention anything but "The American Organ Journal," edited by J. M. Coward (Metzler). Thirty numbers of this excellent work have been published so far, and there is nothing of its kind better or more comprehensive.

Song Accompaniments. In addition to its use for the church service, for which it is so well adapted, the harmonium is also equally adapted, from the extent of its orchestral resources and power of expression, for the drawing-room or concert-room. "The harmonium," says Berlioz, the great composer, "is at once a church instrument and a theatre instrument, a drawing-room and a concert-room instrument. It occupies but little space, and it is portable. It is therefore a servant of indisputable utility for composers and amateurs." It is not necessary to enlarge upon this, but a word or two must certainly be said about the harmonium as an accompaniment to the voice and in conjunction with other instruments. With regard to the first-mentioned use, if heard properly, as the late Dr. Rimbault said, the harmonium will be pronounced not only capable of producing some of the most charming effects of accompaniment, but to possess powers of assisting the voice of the highest possible order. One practical hint: in accompanying songs from a piano copy, alterations will of necessity be made to suit the peculiar nature of the sustaining instrument. Octaves in the bass must be used sparingly, as the lower registers of the harmonium are powerful. When octaves are required in the right hand, it is generally best to get them by drawing the *Clarionet* stop. Again, repeated notes in piano copies should, as a rule, be held when played on the harmonium. But no fixed rules can be given. Much must depend upon the knowledge and acquirements of the performer.

Combination with other Instruments. As regards combination with other instruments, the chief thing to aim at, when an artistic effect is desired, is contrast of tone. Thus the flute does not "go" nearly so well with the harmonium as the violin. The best, as it is the most generally available combination, is that of harmonium and piano. "We cannot conceive," says Dr. Rimbault, "a more perfect drawing-room orchestra than the piano and harmonium when used in concert. Nothing can be more admirable than the combination of the strings of the former with the reeds of the latter, the one imitating the whole tribe of the violin class, the other the entire wind band, and forming together a *tout ensemble* capable of giving effect to orchestral works of the highest class." Special arrangements are, of course, required for this duet playing.

Any good music-seller will show a selection of such arrangements, but the student might ask to see some of those published by Messrs. Chappell and Messrs. Novello, particularly the latter's six duets of L. Engel and the "Transcriptions of Favourite Airs" of C. L. Krug. There is also a considerable quantity of music for harmonium with other instruments, such as violin, 'cello, clarinet, etc. Harmoniumists should lose no opportunity of practising with any suitable instrument available, such practice being of the highest value, not only from an artistic point of view, but also for cultivating the sense of *tempo*. When you are playing with another, you *must* "keep time."

Practice Hours. A few general hints, in closing, on the best method of practice: It must not be desultory. Three hours to-day and ten minutes to-morrow and nothing at all for a week can never mean any real advance. Let practice be regular and systematic. The precise amount of time will, of course, vary according to circumstances. The minimum for the amateur should be about an hour and a half daily. Whatever it is, the time should be well apportioned among the different kinds of work undertaken. The student should draw up a table specially for his own use (and rigidly adhere to it), but the following proportions for an hour's practice will generally be found advantageous:

	Minutes
Finger exercises, scales, etc. ..	20
New piece	20
Piece already learnt	10
Sight reading	10

Above all, let your practice be in thorough earnest, that no moment may be wasted. And always remember the words of Schumann: "Whenever you play, let it be as though a master were listening."

Harmonium and American Organ concluded

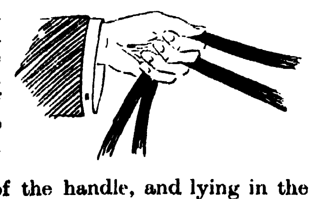
Continued from page 3984

By HENRY CHARLES MOORE

THE desire for an outdoor life is very strong in young men, and many to whom the thought of having to earn a living in shop, factory, or office is distasteful enter the service of the various public carriage companies. And now that motor traction is competing successfully with horse-drawn vehicles, the aspirant for an outdoor life has the choice, assuming that he wishes to be a driver, of becoming a "whip" or a motor man. In the latter capacity his prospects of regular and long service will be greater than if he became a coachman, as the proprietors of horse-drawn vehicles are already reducing the number of their drivers, and in three years' time will need the services of very few of such men. There are, however, men who have a strong dislike for engines and machinery of any kind, and they will probably prefer to drive a pair of horses as long as such employment is obtainable.

The horses used for public service vehicles are harnessed and put-to by the stablemen, but as carelessness on the part of one of these men may result in an accident, and possibly loss of life, the driver before mounting his box should see that the work has been done properly. This he can do unostentatiously while patting his horses. When a change of horses is being made he can see from his seat whether everything is in order.

How to Drive. Having mounted his seat and received the reins from the stableman, the driver should sit with his feet slightly in advance of his body, and on no account put them under the seat or press them against the splash-board. His left elbow should be a trifle above and a little to the front of the left hip bone, with the forearm inclining across the body and the wrist bent. The first and second fingers of the left hand should be placed between the reins, the left or near-side rein resting on the knuckle of the left forefinger; the right or off-side rein should be between the second and third fingers. The third and fourth fingers should press the loose end of the reins on the palm of the hand. The whip should be in the right hand, held at the top of the handle, and lying in the palm of the hand and over the thumb. When held thus the fingers are free to take the reins should it be necessary to use two hands.



The rule of the road is to keep to the near-side when meeting another vehicle; on overtaking one, the driver must pass on the off side of it, unless the vehicle overtaken be a tramcar, when it must be passed on the near side. Obelisks, street refuges, and other erections in the centre of the road must be passed on the near side.

Horse-drawn Omnibuses. The applicant for employment as driver of a horse-drawn omnibus must be accustomed to driving. This statement is not superfluous, for it is made with the knowledge that men who cannot drive frequently apply for work as omnibus drivers, believing that if they are promised employment they will soon be able to learn to drive a pair of horses. It is also imperative that, before making an application for work, the would-be driver should possess a police licence, as omnibus proprietors do not entertain applications from unlicensed men, no matter how excellent their recommendations may be.

When the police have satisfied themselves as to the respectability of an applicant for a licence, they test his proficiency as a driver by setting him to drive an omnibus, which they keep for this purpose, through some of the most crowded parts of London. A police inspector accompanies the applicant on his trial drive, and decides whether or not he shall be granted a licence. If the inspector considers that the applicant is not sufficiently experienced, he tells him that he must undergo another driving test, in two or three weeks, before a licence can be given to him. In these circumstances the applicant will be wise if, in the meanwhile, he has some practice on a heavy pair-horse vehicle, and obtains advice from an experienced omnibus driver.

When the driver has passed the test he has to pay 5s. for his police licence and 2s. 6d. deposit for his badge. The latter sum is returned to him on his giving up his licence, but the 5s. has to be paid annually.

Securing Employment. The newly licensed driver may succeed in obtaining work from the first company to which he makes application, but it is quite possible that he will have to undergo the unpleasant experience of being told time after time that no drivers are wanted. In that case all he can do is to leave his name and address at the various offices, and wait until a vacancy occurs. When at last he is given work he will be surprised to find that, although he holds a licence, his employers do not consider it to be a guarantee that he is thoroughly competent, and therefore he has to make several trial journeys. On these occasions an experienced and trusted driver sits on one of the front seats to watch him, with a view of reporting to his employers whether or not he is a capable coachman. In addition to this, he tells him where

the "points" or stopping places are, and gives him other information which it is necessary he should possess. If the report be satisfactory, the new driver is engaged as an "odd man," which means that when a regular driver, or "service man," is absent through illness, or some other cause, he takes his place. Very probably he will get only one or two days' work during the first week; but he may be fortunate and begin with several weeks of unbroken work. When at last a vacancy is caused by the death, resignation, or discharge of a regular driver, the "odd man" gets his "service," and henceforth he has regular employment. "Odd men" are not, however, always new hands; a "service man" is sometimes reduced to an "odd man" for carelessness, or breaking the rules of his employers. Drunkenness while on duty is an offence which is punished by instant discharge.

Wages. Omnibus drivers are paid 6s. for a day of, on an average, twelve hours. Each man uses between ten and twelve horses a day, according to whether the road be hilly or not, the distance travelled by each pair being about sixteen miles. Sometimes a man who is a good driver is careless about the condition of his horses, but coachmen of this type do not remain long in the employ of an omnibus proprietor. It may be said, too, that if a man has any showy mannerisms, such as squaring his elbows when driving, he will be wise to break himself of them as quickly as possible, as the proprietors have a strong objection to "flashy" drivers. The left hand, it has been said, was made for driving, and the man who makes a practice of using both is another type which does not find favour with employers. For the driver who proves himself to be a good judge of horses there is the chance of promotion to the position of district horse-superintendent, with a salary of from £3 to £4 a week.

Conductors. It is as necessary for a would-be conductor as for a driver to obtain a police licence before applying for work. This is by no means difficult to obtain if the applicant be a respectable man, a few questions as to his knowledge of the main thoroughfares being the extent of the examination he has to undergo. For his licence he has to pay the same as a driver, and he, too, begins as an "odd man." But before becoming even an "odd man" he must take one or two journeys, unpaid, to learn his duties, his instructor being a reliable and experienced conductor. The novice watches the conductor on the first journey, learning the extent of the various fares, the sections in which to punch the tickets, and how and when to enter the unissued ones on the waybill. On the second journey the old conductor hands over to the learner his tickets and bell punch, but watches to see that he charges the right fares, and punches and issues tickets of corresponding value.

At the close of each day the conductor pays out of the takings the driver's and his own wages. The balance he delivers, on the following morning, at the district office, handing in at the same time his box containing the bell punch that he used on the previous day and the unused tickets. The box and its contents are then forwarded to the chief traffic office to be checked. A fresh bell punch, set of tickets, and waybill is issued to the conductor every evening, so that he can begin the following day with a fresh outfit. On the back of each waybill is printed a money table, and if the conductor has issued during the day 151 penny tickets, 47 twopennies, and 23 threepennies, he can see at a glance that he has to pay in 12s. 7d. for the first, 7s. 10d. for the second, and 5s. 9d. for the third.

Hours and Pay. Conductors work the same number of hours as the drivers, and are paid 4s. 6d. a day. Many of the ticket inspectors are drawn from the ranks of the conductors, but, from a monetary point of view, this is scarcely promotion, as the wages of the inspectors begin at 30s. a week, rising to 35s., for which they are on duty eight hours a day. One week they begin work at about seven o'clock in the morning, the following week they go on duty at about four in the afternoon. Another and more profitable position to which conductors can rise is that of road inspector, with wages of from £3 to £4 a week. Timekeepers, many of whom are old drivers or conductors, are paid from 30s. to 35s. a week; horsekeepers receive about 28s. a week; and the 'bus washers, whose work has to be done at night, are paid from 35s. to 40s. a week.

Motor Omnibuses. The old-established omnibus companies being naturally desirous of retaining as many as possible of their old servants, take their motor omnibus drivers from the ranks of the coachmen and conductors of their horse-drawn vehicles. Most of the companies have, at the present time, a long list of men who are being taught, or are waiting to be taught, motor omnibus driving. Usually they are taught at the expense of their employers, but in return are required to sign an agreement binding themselves to remain in their service for a specified period, in most cases a year. It will be seen, therefore, that for some years to come the old-established companies will be able to obtain from among their own servants all the motor drivers they require, and that consequently the man who is not already in their employ has little chance of entering their service as motor man. But with the new companies it is different. Having no horse-drawn omnibuses, they have no old servants to whom they feel bound in justice to give preference, and consequently they are able to consider the application of any man, qualified or unqualified, who wishes to enter their service. Both the old and the new companies have their own instructors, by whom the men are thoroughly taught driving and mechanism before being sent to New Scotland Yard to undergo their police examination.

Examination for Motor Omnibus Drivers. In the interests of the public, the examiner, an inspector of the Public Carriage Office, subjects each applicant for a licence to a very thorough set of tests. First he is examined in backing and turning the omnibus, and if he comes through this ordeal successfully he is told to drive out into the street. The examiner sits

beside him, and decides the route he is to take during the hour's run. A part of the time is spent in crowded streets, and if the driver be unfortunate enough even to graze another vehicle he is put back for two or three weeks; if, however, he satisfies the examiner that he can drive carefully in the midst of traffic, there is the hill test to be undergone. He is told to drive to a fairly steep hill, and as he is ascending it he must stop the omnibus, and start it again, whenever the examiner commands. The same test is applied while descending the hill. If the examiner be satisfied that the man is thoroughly competent he is given a licence to drive an omnibus of that particular type; but if, after a time, he wishes to drive an omnibus of another make he must undergo another examination. This is an excellent police regulation, for there are many types of motor omnibuses in use, the châsses of which differ considerably in many respects.

Licences. For his licence the motor omnibus driver must pay 5s. to the police, 2s. 6d. deposit for his badge, and 5s. to the London County Council. After receiving his licence the driver soon obtains his "service," for qualified motor-'bus men are not yet so plentiful that they have to remain long as "odd men." Moreover, as motor omnibuses are on the streets from eighteen to twenty hours a day, it is necessary to have two drivers and two conductors to every 'bus, one pair of men working the first half of the day, the other relieving them after about nine hours, and working until the 'bus is taken into the garage for the night. Drivers are paid 7s. a day, and conductors 5s. Mechanicians, who overhaul the motor omnibuses every night, are paid 35s. a week, and 'bus washers 30s.

The Motor Omnibus Business. To start business as a motor omnibus proprietor it is necessary to have plenty of capital, for £1,000 barely covers the cost of one vehicle. Moreover, the man who possesses only one or two motor omnibuses has little chance of competing successfully with the large companies, who can, of course, work at a lower cost per vehicle than is possible for a proprietor in a small way of business. Competition between the old and the new companies will become keener every month, and the result will be a cutting down of fares that will make it absolutely impossible for the owner of only one or two vehicles to run them at a profit. If, however, a man has plenty of capital, and decides to build up a fleet of omnibuses, he should endeavour to discover the various types of châsses that are giving satisfaction to their owners, and should restrict his choice to them. It will be much safer to do this than to purchase, even at a much lower figure than is demanded by makers of repute, a type of omnibus that has not undergone the test of some months' work on the public roads. When he has bought his châssis, it will have to be taken to a coachbuilder's to have a body built and fitted to it, for the makers of châsses do not, as a rule, build the bodies, that being quite a separate business.

Motor Omnibus Regulations. When the body has been fitted to the châssis, the omnibus is ready to be licensed; but it is useless to submit it for police inspection unless the following regulations have been observed in every respect:

"Carriages must be submitted for inspection in a thoroughly good condition, and no carriage will be certified fit for public use unless it is newly painted and varnished."

The following conditions must also be strictly complied with:

1. Stage carriages propelled by mechanical means, and subject to the Light Locomotives Act (59 and 60 Vict., Cap. 36), and Motor Car Act (3 Edwd. VII., Cap. 36), must comply with the requirements of those Acts, and of the Orders of the Local Government Board in pursuance thereof.

2. Each new type of motor-car intended for licensing must be presented at New Scotland Yard for inspection. The proprietor must at the same time produce the certificate of registration, and also one from the maker stating the machinery to be safe, and in every way fit for use in a public carriage.

If, on inspection, the car is approved, such approval may extend to all cars of that description, and cars of that type need not be again presented at New Scotland Yard, but may be taken to the usual passing station, provided a certificate from the maker is submitted with each car for licensing, stating that it is in every respect similar to the type already approved.

A certificate from the proprietor, stating there has been no alteration in the design of the machinery since the previous inspection and date covered by the maker's certificate, must be presented with each car submitted for renewal of licence.

Should an alteration be made, the same course may be required as for a first inspection.

Should it be deemed necessary, an expert will be employed to advise on the subject. The fee for the expert examination to be deposited by the proprietor with the Commissioner, which fee will be returned if the car is passed without alteration being required.

There are specific regulations governing the construction of motor omnibuses, and licences are granted only for vehicles in the construction of which those regulations have been followed. The regulations specify the sizes of the various parts of the vehicles, and their details may be learned upon application to the licensing authority.

The fees to be paid to obtain a licence for a motor omnibus are £3 18s. to the Inland Revenue, £2 to the Metropolitan Police, and £1 to the London County Council. The last-mentioned fee is paid on the first year only; the other two are payable annually.

Cabs and Cabmen. The applicant for a cabman's licence, having satisfied the police as to his respectability and topographical knowledge, has to undergo a driving examination, usually on a four-wheeler, and with a police official sitting beside him on the box seat. The regulations, being subject to the local police arrangements, vary in different places. The London candidate, if passed by the police, is given a licence, renewable every twelve months, for which he has to pay 5s., and a deposit of 2s. 6d. His next step is to obtain a cab to drive. Cabmen differ from omnibus and tram men in not being the servants of the proprietors of the vehicle they drive. They

hire them from a proprietor, paying a certain price per day. The average price per day for a hansom works out at 11s. 3d.; for a four-wheeler at 10s. 6d. Two horses are supplied for each cab. Drivers of "privileged" cabs have to pay an extra fee. The "privilege system" is an arrangement between the railway companies and certain cab proprietors, whereby a specified number of vehicles belonging to the latter are permitted to enter the various London termini and stand there for hire. As this ensures the drivers getting more "fares" than they would obtain if plying for hire in the streets, it is reasonable that they should have to refund to the proprietors the price paid per vehicle to the railway. At some railway stations the charge is 1s. per cab per day; at others it is as high as 4s.

Cab Fares. The following are the London cab fares. The cab radius is four miles from the statue of Charles I., at Charing Cross:

By Distance.	s.	d.
If hired and discharged *within* the radius, for any distance not exceeding two miles	1	0
For every additional mile or part of a mile	0	6
If hired *outside* the radius, wherever discharged, for the first and each succeeding mile or part of a mile	1	0
If hired *within*, but discharged *outside* the radius, the whole distance, not exceeding one mile	1	0
But exceeding one mile, then for each mile ended *within* the radius	0	6
And for each mile or part of a mile outside	1	0
By Time.		
Within the radius, four-wheeled cabs, for one hour or less	2	0
Hansoms, per hour	2	6
For every additional quarter of an hour, or part of a quarter, four-wheelers	0	6
Hansoms, per hour	0	8
Four-wheelers or hansoms, if hired *outside* the radius, wherever discharged, for one hour or less	2	6
If above one hour, then for every quarter of an hour or less	0	8
If hired *within* but discharged *outside* the radius the fares are according to the two preceding paragraphs.		
Luggage.		
For each package carried outside	0	2
Additional Persons.		
For each person above two (two children under ten years of age are regarded as one person)	0	6
Waiting.		
By distance only. For every fifteen minutes completed, if hired *within* the radius:		
Four-wheelers	0	6
Hansoms	0	8
When hired *outside* the radius, four-wheelers or hansoms	0	8

Unless the cabman is told when hired that he is engaged by time, fares must be paid according to distance. A driver can refuse to be hired by time between 8 p.m. and 6 a.m.

A cabman hired by distance must, unless prevented by the traffic, drive at the rate of six miles an hour; if hired by time, four miles an hour. Should he be requested to drive above the latter speed, he may demand, in addition to the time fare, for every mile, or any part of one, exceeding four miles, the fare regulated by distance.

The Taxameter. Disputes between cabmen and riders concerning the fare to be paid will continue to be numerous until some distance registering apparatus is affixed to every cab. The taxameter was tried on a few London cabs in 1899, but owing to the opposition of the cabmen as a body, the experiment was short-lived. At the present day the objection to the taxameter is not nearly so widespread among cabmen, and there is every probability that before long it will be given a fair trial; a commission of inquiry into the subject has, indeed, reported this year (1906) in favour of its adoption. Somewhat resembling a clock in appearance, it is fixed over the off-side wheel, and records at the end of every journey the distance that has been travelled and the fare to be paid, including extras for luggage and waiting. It registers also the number of journeys the cab has made, the miles travelled, and the total takings of the day. When the cab is plying for hire, a little red flag projects from the side of the taxameter, and the words "Not engaged" appear on the dial. When a passenger enters the cab, it is the driver's duty to press down a lever, which causes the flag and "Not engaged" to disappear, the latter being replaced by the tariff. On arriving at the passenger's destination, the driver pulls up the lever, whereupon a record of the distance travelled and the fare to be paid appears on the dial.

Many cabmen are the proprietors of the cab they drive. In the majority of cases the man originally drove for some other proprietor, but having saved money, started business on his own account. A hansom or four-wheeler can always be obtained on the hire purchase system, and a couple of cab horses can usually be bought at a low figure if a man is prepared to spend some days at the horse repositories waiting for an opportunity to buy cheaply.

Cab Radius. As already stated, the London cab radius is four miles from the statue of Charles I. at Charing Cross. Its extension has been advocated frequently, but it is unlikely that any alteration will be made while horse-drawn cabs are in vogue. When motor cabs are plentiful, the proprietors and the drivers of the latter will probably ignore it if it be not considerably enlarged. An important section of the drivers of horse-drawn cabs—the men who ply for hire in the City and the West End—are very rarely engaged to go beyond the radius, and consequently it is a matter of indifference to them whether it be extended or not. The cabmen who do object to any alteration are those who stand for hire just outside the four-mile limit, for they appreciate being able to charge a person who hires just outside the radius "outside" fares for the whole distance travelled inside the radius. Their reply to the fact that if they charged "inside" fares they would carry more people to the West End is that they would then lose their most profitable jobs—the short shilling journeys from railway station to private houses.

Motor Cab Regulations. The conditions to be complied with before submitting a motor cab for police inspection are, to a great extent, similar to those framed for motor omnibuses; but the following are some of the special regulations. The height of the body of a hansom inside, from the top of seat cushion to the roof at the lowest part, or where the front window-frames fold up toward the roof to the lowest part of the frame, must not be less than 40 in., the width inside at any point, not less than 40 in., the width from the back squab to the nearest point of door pillars, not less than 26 in., and for knee space, not less than 28 in. The height of body of a brougham or landaulette, from the top of seat cushions to the roof at the lowest part, must not be less than 40 in., the width between the hinge pillars or shutting pillars, not less than 40 in., the width of door, not less than 21 in., and it must be so constructed that it opens to the fullest extent, and causes no inconvenience to passengers. Where the carriage is provided with front and back seats, the measurement between the front edges of cushions must not be less than 19 in., the width of front seat not less than 14 in., and of back seat not less than 16 in.

Tramways. The London County Council being the proprietors of the majority of the tramway services in the metropolis, the man who is desirous of becoming the driver or conductor of a tramcar, horse-drawn or motor, cannot do better than apply for employment to the chief officer of L.C.C. Tramways, 303, Camberwell New Road, S.E. Both drivers and conductors of the horse-drawn tramcars work six days a week, the rate of pay being for each 4s. 9d. a day on entering the service; 5s. 3d. after six months, or on obtaining a service car; 5s 9d. after six months on a service car; and 6s. 3d. after twelve months on a service car. Men are promoted from "spare" men to "service" men, as far as possible, according to seniority of service. Every driver and conductor receives also a uniform coat, overcoat, and two hats a year. Stablemen are paid 26s. a week; washers, 25s. to 30s.; farriers, 39s. to 43s. 6d.; track cleaners, 25s.; pointsmen, 24s.; trace boys, 14s. to 18s.; ticket inspectors, 42s.; regulators, 42s.; and night inspectors, 42s. All the above-mentioned work six days a week, the total number of hours per week being 60, except in the case of farriers, who work 54 hours. The only men who work seven days a week—total number of hours 70—are the foremen and deputy foremen, whose pay respectively is from 42s. to 64s. 6d., and 42s.

The drivers and conductors of motor tramcars receive the same pay as the drivers and conductors of the horse-drawn cars, but they work 56 hours per week instead of 60.

When any of the L.C.C. tramway employees are requested to work during their "stand off" or "resting" time they are paid at the rate of time and a quarter.

The conditions of employment under tramway companies and on the municipal tramways of the provinces vary, but the conditions in London may be regarded as typical.

Jobmasters. Any man who is energetic and a good judge of horses should be able to work up a profitable jobmaster's business. Two or three hundred pounds would be sufficient capital for a man starting in a very modest way, as broughams and landaus can be obtained on the purchase by instalment system, and the hay and corn merchants will give him credit, if he is a respectable man. Sometimes the hay and corn merchant will advance money to a man desirous of starting business as a jobmaster, but it is advisable to dispense with this assistance if possible, and be free to buy hay and corn in the cheapest market.

For every vehicle which a jobmaster lets out he has to pay 15s. for a licence. His coachmen are paid from 23s. to 35s. a week; but as their duties include the ordinary stable work, horse-keepers are not necessary. Many jobmasters do a good business with commercial travellers' broughams, which they let out at about £12 a month, this sum including horse and coachman. The wages of the coachman are about 23s. a week, but this sum is augmented by tips which he receives from the commercial traveller, the amount varying according to the prosperity and generosity of the donor.

No licence has to be paid for the letting out of saddle horses, and in some neighbourhoods this branch of a jobmaster's business is very profitable.

On important State occasions, when the nation's guests are numerous, the Royal stables are unable to meet the demands for carriages, with the result that some of the leading jobmasters receive orders to supply a certain number of broughams, landaus, and, occasionally, hansom cabs. The jobmasters naturally appoint their best coachmen to drive these carriages, and the selected men usually receive a handsome gratuity from the distinguished persons whose coachmen they become for the time being.

Carmen. Of all drivers, carmen are the worst paid, their wages ranging from 16s. to 32s. a week, the higher sum being received by the men who drive a pair of horses. They work on an average 14 hours a day, but, unlike most workers, have no settled times for meals, and must get them when and where they can. Whenever a carman leaves his vehicle to obtain a meal he runs the risk of being summoned by the police for leaving it unattended, and having to pay a fine of from 2s. 6d. to 15s. and costs. The London carmen, of whom there are some 45,000, are endeavouring to get Parliament to sanction the provision of registered stands where they could leave their vehicles in safety when they wish to obtain food. Such stands are very badly needed.

Continued

Group 19 JOURNALISM 3 Continued from page 3978	THE REPORTER & HIS WORK
	First Years of Reporting. Shorthand. Telegraphing Copy. Longhand Abbreviations and Press Corrections. The Reporter's Environment. Helpful Qualities

By ARTHUR MEE

WE have reached the door of the newspaper office, and the work of him who steps inside will begin to take definite shape. He may never have been in a newspaper office before, and his first impression, perhaps, will be one of surprise at the utter simplicity of everything he sees.

He will remember what a wonderful thing a newspaper is; how it reaches to the very ends of the earth, and how it brings, or how it should bring, the beating heart of all the world to our own firesides. He will know that nothing can happen in any far-away corner of the world which will not some time, in some way, make itself known in the room he has entered. Yet all that he will see before him will probably be a few chairs and tables at which men are writing or reading telegrams. He will find, no doubt, his first encouragement in this. The simpler the conditions, the more hopeful he should be; and the man whose work needs no other tools than a fountain pen and a pad of paper can hardly wish for an environment more free from mystery and technicality.

The Reader's Room. Journalism has many destinies, and the time will soon come when our candidate must make up his mind which of these he will choose. He will have to decide whether he would like to be a reporter or a sub-editor, or whether he would rather aim for one of the other various posts a newspaper has to offer. But that time is not yet, and for practical purposes his work will be, for the first year or two, precisely the same whatever ultimate goal he has in view. The first business of the journalist is to be ready to do anything.

It should have been pointed out before, perhaps, that journalism may be very easily entered through a department of the composing room. One of the most important figures in a newspaper office is the reader, to whom is entrusted the business of correcting proofs. The reader's room, one of the busiest corners in a newspaper office, affords an excellent opportunity for an introduction to newspaper work, and a boy may enter this department as a copyholder much earlier and more easily than he can possibly enter the reporter's room. It will be his duty here to read copy aloud to the reader, who will compare it with the proof and make any necessary corrections. The training in this work will help considerably to prepare him for journalism, and this way of beginning may, indeed, be strongly recommended from many points of view. A year in the reader's room will enable a boy to form an opinion as to his liking for journalism as a career, will make him careful and quick to detect error, and will in many ways help to put him on the road he is anxious to tread.

The Journalist's First Work. But, whether with or without this experience, he will begin his real journalism in the reporter's room, and the first few years of his life here will be decisive of his place in his profession. He should never forget that his first duty to himself as well as to his paper is to gather experiences wherever he can, whenever he can, however he can; and he must be prepared to think nothing of hard work, of long hours, of irregular meals, of weary miles of walking by night, of unexpected demands to begin again at the end of a trying day. Journalism has no room for the man who must go home when the clock strikes.

Only one thing is automatic in journalism—the hour of going to press. It is the irregular and ever-changing nature of his work which the young journalist will come to regard as its chief value and charm. But he will find that at first his work lies in a well-defined field, and that he is given the responsibility of "covering" several regular and necessary appointments.

He will have become an apprentice, no doubt, on the staff of a provincial paper in a town such as, say, Nottingham. We may quite safely assume that he is in the provinces, because it is utterly impossible for a reporter to begin his career on a London newspaper. It is, indeed, impossible to begin newspaper journalism at all except in the provinces. It will be helpful, therefore, to take a swift survey of the ordinary work of a reporter in a typical provincial town, in the office of a morning paper with an evening edition, and the reader should bear in mind that it is precisely this kind of work which the young journalist is sure to be called upon to do at the outset of his career.

The Reporter's "Calls." The day begins with a series of calls which, though made by the junior member of the staff, are of the greatest importance. The coroner's office, the fire station, the police station, the hospital, must be called at early every morning; at 9 or 10 o'clock, or earlier, according to the time at which the paper appears. Let us go with the reporter on his round.

At the coroner's office he learns of some fatal accident, some sudden death, or some death by violence, and the brief statement of particulars which the coroner's officer allows him to see gives the essential facts. If an inquest is to be held the reporter notes down the time and place. At the hospital he may glean particulars of some street accident which has not proved fatal, and has therefore not come to the notice of the coroner; and there are many kinds of information which he may acquire by keeping in close touch with the hospital authorities.

So, too, at the police and fire stations, usually close together. The reporter may learn here of some probable development in the local courts that morning, of some interesting arrest, or of some outbreak of fire. With the necessary information about these things in his notebook he returns to the office and presents his report to his chief. If the matters are of minor importance he may be asked to write paragraphs concerning them, and this may be considered adequate treatment of the circumstances. Should there be any special interest, however, in any of the cases, the chief reporter will enter the event in a diary to be "followed up," either by the junior himself or by one of the senior reporters.

The Reporter's Diary. The diary is the most important and exciting book in the office. It is the genesis of the next edition of the paper so far as local events are concerned, and there are times in every reporter's life when he approaches this book in fear and trembling. He may find himself marked to take the next train to Manchester, or Birmingham, or Exeter, or Cardiff, to send a special account of a railway accident, a description of a political meeting, an interview with a man who has suddenly become of local interest, an investigation of some commercial enterprise closely concerning the readers of the paper. He may find himself sent away for a week to follow a candidate through a by-election, perhaps in some remote constituency in the depth of the winter. His fate for the day, whatever it may be, is settled by the diary.

It is the duty of every reporter to see that every interesting event that takes place in town is entered in the diary, and the junior may make himself very useful to his chief by keeping his eyes wide open for public announcements. It will be his duty also to familiarise himself with the dates of regular meetings which must be attended, and to see that these are carefully entered. The monthly meetings of the local authorities, the meetings of the town and county councils, the education authority, the parish and district councils, the annual meetings of societies, are all stock engagements which should never be left to casual recollection, but should be entered in the diary a year ahead. Notifications of most events are sent to the office by those concerned in them; but the vigilant reporter never relies on secretaries, and every day events occur of which no notification is sent. It is the duty of the reporter to see that these functions are not missed.

What the Reporter Should Know. The wise reporter will know something about most of the things that happen in the town. He will know not only when an annual meeting is to be held, but what is likely to be discussed at it. He will be friendly with all sorts and conditions of people, with employers of labour, with working men's leaders, with social workers, with ministers and clergymen, with lawyers, shopkeepers, police officers, builders, doctors, workhouse officials, town councillors and poor-law guardians, librarians, and a host of other people in all sorts of posts and places. The whole world is his idea-box, and the reporter never knows when there may be a column of "copy" in the most casual remark of somebody he meets. He may be attending a public meeting in a neighbouring village, and may find himself chatting with the chairman, who is, let us say, the local estate agent and valuer. Has the reporter ever thought of the copy that lies unused in a valuer's office? If he is used to seizing opportunities, he will discover that his valuer friend knows the ins and outs of all the little businesses in the neighbourhood—how they pay, their market value; what kind of business succeeds and what kind fails, and why; the factors that make one tradesman's life prosperous and happy and another a tragic failure. He will find a veritable mine of information of economic value and great public interest in the man whose business it is to know the comparative values of things in our villages and towns.

The Value of Shorthand. It will have been gathered already that a reporter's life does not by any means consist in the mere writing of shorthand and the transcribing of his notes. With the development of journalism the reporter has become largely merged in the descriptive writer. There will, no doubt, always be a demand for notetakers; but there is no demand for men who can merely take notes.

One of the most successful journalists of our time, Mr. T. P. O'Connor, has said that a journalist will succeed better without shorthand than with it. What he means is, probably, that the journalist is better without shorthand *when he has gained experience*. It is undoubtedly true that the man who succeeds in journalism without the use of shorthand is the best journalist, because his journalism is the sheer triumph of his own native ability without any mechanical aid such as shorthand gives; and in succeeding without shorthand he develops qualities a thousand times more valuable to him than shorthand could ever be.

But we live in a world where journalists are not born with a T.P. pen in their hands, and it is still true that the broad way that *leads to* journalism is by Pitman's shorthand. No ordinary young man has the slightest opportunity of joining a newspaper staff unless he learns shorthand, and this great fact is in itself an answer to those who declare that shorthand is unnecessary. While, therefore, the young journalist will fight against any inclination to trust to his shorthand as to a crutch, he will not fail to use it as a walking-stick—if one may adopt Sir Walter's famous simile.

We have considered some of the duties which will make demands upon the reporter's notebook, and there are countless others. Every day there may be police courts sitting in which the reporter must make careful notes of the evidence of witnesses and legal statements. Not a day passes in which a careless reporter would not run the risk of involving his paper in an action for libel. Even such simple matters as the use of the word "prisoner" for "defendant," and the necessity of guarding a report in accordance with the theory that a man is innocent until he

has been proved guilty, will cause the reporter much anxiety at first.

Pitfalls in the Reporter's Path. He must take care to realise the many pitfalls that lie in his path. He should never, when learning his work, resent the advice of a more experienced colleague. He should never allow himself to lose the sense of responsibility, to forget that the thing he writes is given to the world and cannot be recalled. The clerk who makes a mistake in his books to-day can rectify it to-morrow; even next week or next month the mischief may be stopped before it has gone too far. But a mistake in a newspaper paragraph goes on for ever. No correction can make it good.

A full sense of this truth will save the journalist from many slips. It will save him from such an experience as befel the writer when, in a mood of unpardonable indifference to all that he is now contending, he betrayed the paper which trusted him. There was in his town a place of entertainment so vulgar that he would not go to it, and his generous chief saved him the pain of rebellion by not marking him for the engagement he held in such contempt. There came a busy night, however, when there was no way out, and the sensitive junior reporter was marked to "cover" the fatal engagement. He would not go. On an electric switch by the fireplace in the reporter's room hung the weekly bills of the music hall; every week the new bill was put in its place on the top. Taking down the top bill, the rebel junior, guarding himself by an assurance over the telephone that the programme was being "satisfactorily performed," wrote a paragraph saying so for the next morning's paper. It appeared, a tame little paragraph in which nobody would have looked for a bombshell, until the manager of the music hall called to know what subtle reason the paper had for declaring that a programme five weeks old had been received the night before with great applause! There are obvious morals to the story, which every junior reporter may apply.

Experience of "Copy." The reporter should strive to create the feeling in the mind of his chief that he can be relied upon. It will be necessary at first for his copy to be revised, but the time will come when he himself will be given opportunities of revising the copy of a newer apprentice, or of the country correspondents who, invaluable as they are to any paper, have sometimes a genius for missing essentials and for writing tediously, in very bad grammar, about trifling things. The value of the good local correspondent can hardly be exaggerated, but the chief value of the bad correspondent is that his copy is a means of teaching sub-editing to those who deal with it. The reporter who is called upon, as all reporters are, to practise sub-editing, will find this experience so useful to him that he should do as much of this work as he can; it will help him to see defects in style, and to achieve a free style of his own.

The bulk of the reporter's work is, however, of a very different kind. His own copy should, after one or two years' experience, be ready for press without any sub-editing. He will learn in these first years much more than any book can teach him. He will have been called upon to test himself at almost every possible kind of function. He will have learned the value of every minute, the use of the telephone and telegraph, the importance of being able to make up his mind quickly how to act, the necessity of utilising time spent in travelling, and of writing with a rapidity he has not thought possible before. He will have found that newspaper work is not all flower-shows and weddings; but he will have found, also, that constant application and organisation make the most difficult things easier.

Reporting a Speech. There is a great difference in the styles of reporting which will come under his notice. The reporter will discover these things for himself, but we will take one example. There was a fine passage the other day in a speech by Mr. Winston Churchill, in which he drew the line between individualism and collectivism. Here is a first-person extract from his speech:

> That is where the Socialists make a mistake. Let us be careful not to fall into it. We have an Army and Navy collectively. Collectively we maintain a Government, police, and Post Office. But we do not make love collectively. We do not die collectively, and it is not collectively that we suffer, and hope, and win, and lose, in a world of accidents and storms.

The reporter who has to report this in the third person need only alter the first two lines: "That *was* where the Socialists *made* a mistake. Let *Liberals* be careful not to fall into it." In ordinary third-person reporting, however, this degenerated into:

> That was where the Socialists made a mistake. Let them be careful not to fall into it. We had an Army and Navy collectively. Collectively we maintained a Government, police, and Post office. But we did not make love collectively, we did not die collectively, and it was not collectively that we suffered, and hoped, and won, and lost, in a world of accidents and storms.

This, of course, is full of absurdities, almost worthy of the reporter who put a quotation from Tennyson into the third person by saying: "The speaker said that kind hearts were more than coronets, and simple faith was superior to Norman blood."

It is unfortunately true that in third-person reporting the practice of unnecessarily altering the present to the past tense is ordinarily adopted, but it is rarely done without spoiling the report, and sometimes quite perverting the meaning, as, say, in the case of a speaker who says: "London is greater than Manchester, and its streets are wider than the streets of Manchester."

This in the third-person style of reporting now common would become: "London *was* greater than Manchester, and its streets *were* wider than the streets of Manchester," the effect of which, of course, would be to give the reader the impression that London was greater than Manchester in the past, whereas what the speaker meant was that it is greater than Manchester now.

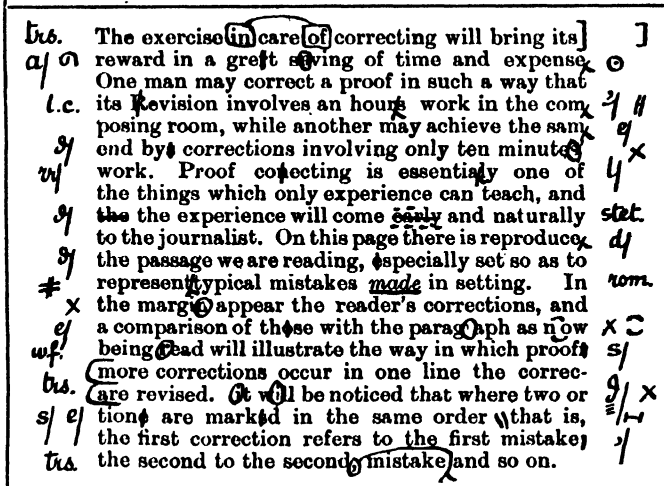
Reporting by Telegraph. The reporter will some day be called upon to send his copy by telegraph, and he will find this quite simple.

The first thing necessary is to obtain from the post-office, free of charge, a supply of Press telegraph forms. On the front slip (Form 1) are the places for the names and addresses of the papers to which the message is addressed; Form 2 is merely for the continuation of the message. Up to 6 p.m. on any day on which the office is open the reporter may hand in a message at any post-office in the kingdom at the rate of 75 words for a shilling. After 6 p.m. the rate is 100 words for a shilling.

There are still telegraph offices in the kingdom where no Press message has ever been seen, but the Post Office rarely disappoints the journalist. It is a condition that notice shall be given of any messages over 200 words, but where this is impossible the rule is readily relaxed. By writing to the secretary of the Post Office, giving him twenty-four hours' notice, the reporter may have any office in the kingdom kept open on payment of a minimum fee. When the message is to be sent to various papers, all that is necessary is to write the names and addresses on the front slip of his message, or to pin a list to this slip, and to pay 2d. instead of a shilling for each subsequent address—that is to say, a message sent after 6 p.m. from London to ten different newspapers in ten towns will be charged for once at the rate of a shilling per 100 words, and nine times at 2d. per 100 words, and it may be sent any number of times at this rate.

	Delete (take out)	≡ or cap.	Capital letters
	Turned letter	= or s.c.	Small capital letters
⁁	Caret (insert)		Indent line one "em"
	Quotation marks		Reduce space
	Insert hyphen	n.p.	New paragraph
	Close up	X	Broken letter
#	Insert a space	w.f.	Wrong fount of type
	Run on into one paragraph	stet. & ∴∴	Ignore correction
[	Break, or new paragraph	rom	Roman type
	Apostrophe	ital.	Italic type
	Comma		Metal rule (—)
⊙	Full point	]	End even
trs.	Transpose words or letters	l.c.	Lower case (small letters)

SIGNS USED IN CORRECTING PROOFS


tr. The exercise in care of correcting will bring its]]
a/ reward in a grest sving of time and expense ⊙
One man may correct a proof in such a way that
l.c. its Revision involves an hour work in the com
posing room, while another may achieve the sam
end byd corrections involving only ten minute
work. Proof coffecting is essentialy one of
the things which only experience can teach, and
the the experience will come early and naturally stet.
to the journalist. On this page there is reproduce
the passage we are reading, dspecially set so as to
represent typical mistakes made in setting. In rom.
X the marg appear the reader's corrections, and
a comparison of those with the paragaph as n ow X
w.f. being read will illustrate the way in which proofs
tr. more corrections occur in one line the correc-
are revised. It will be noticed that where two or X
tions are markd in the same order that is,
the first correction refers to the first mistake
tr. the second to the second mistake and so on.

HOW TO CORRECT PROOFS

This passage appears in its revised form on this page as part of this article, and the actual passage should be compared with the above

Rapid Writing. It is not possible for us to consider here, even in this brief fashion, all the practical things that a reporter must know. He will come to learn them as he goes along. He should never be satisfied with himself so long as it takes him more than an hour to write out a thousand words in longhand from his notes. The reporter's ideal is the House of Commons Gallery man who once wrote three columns of the TIMES (over 6,000 words) in three hours.

To facilitate rapid writing of longhand a series of abbreviations is recognised in every printing office and in every post-office. They are:

/=the, fm=from, f=for, wd=would, o=of, shd=should, t=that, h=have, wl=will, w=with, wh=which, cd=could.

Many other abbreviations will readily suggest themselves—such as, for instance, *g* for *ing*; *n* for *tion*—that is, *speak^g* for *speaking*; *terminat^n* for *termination.*

Of even greater importance is it that the journalist should learn how to correct proofs. The exercise of care in correcting will bring its reward in a great saving of time and expense. One man may correct a proof in such a way that its revision involves an hour's work in the composing room, while another may achieve the same end by corrections involving only ten minutes' work. Proof correcting is essentially one of the things which only experience can teach, and the experience will come early and naturally to the journalist. On this page there is reproduced the passage we are reading, specially set so as to represent typical mistakes made in setting. In the margin appear the reader's corrections, and a comparison of these with the paragraph as now being read will illustrate the way in which proofs are revised. It will be noticed that where two or more corrections occur in one line the corrections are marked in the same order—that is, the first correction refers to the first mistake, the second to the second mistake, and so on.

The Reporter's Difficulties. The reporter should learn to write in almost any conditions. He may have to take notes in a

crowd, holding an umbrella, or hanging on to a lamp-post. He will find great difficulty at times in obtaining names at meetings; will suffer much inconvenience from the neglect of secretaries, the mistakes of speakers, the bad manners of many people who ought to know better. He will be insulted by people who imagine that every reporter has his price—from the poor woman who, knowing no better, offers him sixpence to keep her boy's name out of the paper, to the man who, knowing better, is not ashamed to tempt him into evil by offering him gold.

The good reporter is oblivious of the difficult or unpleasant circumstances in which he may find himself at times. He will think nothing of having to write in trains—that, if he will sit facing the engine and write on a stiff board, letting his back come into contact as little as possible with the carriage, is easy. He will accept a difficult engagement quite readily, knowing that the experience will make the same work easier when it comes again, until difficulties cease to trouble him. He will learn to have a contempt for such men as the reporter on a London morning paper who, having been engaged in the office for some time, was told to do outside work. "But I am no good at outside work," he said. "Well," said the editor, "that is all I have for you." "Well, I had better take my pay and go," said the stupid reporter, and one of the most go-ahead halfpenny papers in London was well rid of him. The reporter who is "no good at outside work" is no good for anything to a newspaper, and it is a most unfortunate day in a journalist's career when he refuses an engagement for reasons of that kind.

A Royal Road to Information. There are many things that the reporter must teach himself. Only his own experience can teach him the priceless value of the gift of holding his tongue and of never expressing surprise.

There is a familiar story of a representative of the TIMES dining with a physician, who mentioned that a statesman had that day asked him if India would suit him. He had answered, "Yes." The TIMES reporter exhibited no surprise and no unusual interest. Knowing that the Viceroyalty was vacant, he went to the office and wrote a paragraph saying that the statesman was to be the new Viceroy of India. He was right. A casual remark at dinner had contributed what may have been the most interesting paragraph in the next day's papers. It was a creditable achievement, and it depended upon four qualities on the part of the journalist. He knew his facts; the Viceroyalty was vacant. He had cultivated his natural powers of deduction; it was not likely to be a mere coincidence that one of the probable candidates for the Viceroyalty should ask at that particular moment if India would suit his health. He had the astuteness not to seem unusually interested; he had all the information he wanted, and knew that any expression of surprise might cause the physician to pledge him to secrecy. He had the courage without which no man ever succeeds in journalism; he did not wait to make further inquiries, which would have lost him the distinction of making an exclusive announcement.

The Man Who Always Knows. It is one of the surest and wisest rules in journalism never to manifest surprise. It is the business of the journalist to *know*, and he should give the impression of a man who knows wherever he goes to seek information. The quickest way of closing a man's lips is to express surprise at anything he has said. He hesitates, pauses to ask himself if he is wise, and at last regrets having revealed a secret. The natural reluctance of men and women to say anything which may involve them in trouble or publicity makes the work of the journalist often unnecessarily hard; and the journalist can smooth the way for himself by taking a startling statement as a matter of course, as if he had been familiar with it all the time. It is not necessary, of course, to point out the difference between a piece of confidential information and information which it is quite legitimate to publish, though the man who can give it is unreasonably nervous about doing so. No reporter worthy of the name will break faith by publishing something he has promised to keep secret. We are discussing now the method of obtaining information or opinions in a quite legitimate manner from persons who, either because of their own nature or because of the circumstances, may be very easily frightened and stricken dumb by the way in which the journalist receives their statements.

The Value of Sympathy in Reporting. The reporter's life brings him into contact with that side of things which is not always the best, but he will, if he is wise, take care that his experiences make him not a worse but a better man. He need not be ashamed of having emotions even as other men. The chief reporter who knows his work well and knows how to get full value from his staff will do his utmost to see that his reporters are sent to sympathetic engagements, and he will do all that he can to encourage rather than repress any enthusiasm the reporter may manifest. The reporter is too often regarded as something apart; a necessary, but not an integral, piece of machinery. He should make it his business to become an integral factor in things, to feel himself a part of, and let others feel that he is a part of, whatever is happening. It is inevitable that the reporter should find himself in the company of people he dislikes, in an environment that is intolerable to him, doing work that he detests; but it is a good thing to bear in mind that the man who will describe a movement best is the man who feels the spirit of it, who knows the aim of it. There was a wonderful article describing a Salvation Army meeting in a London paper not long ago. It was written by a reporter who calls himself a Freethinker, but who had the greatest difficulty to keep away from the penitent form as he listened to Miss Eva Booth. It is not astonishing that he wrote a wonderful article. The reporter who puts his soul into his work will carry everything before him.

Continued

DRESS FOR LITTLE BOYS

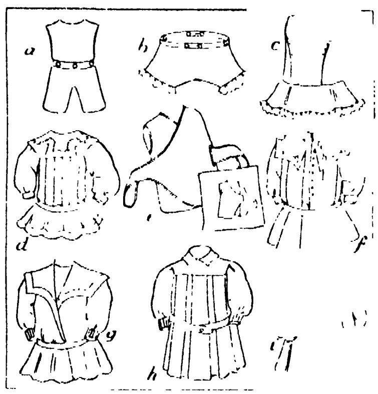
A Set of Garments for Little Boys. Tunic and other Suits. The Popular "Man-o'-War." A Scotch Kilt

continued from page 4051

By AZÉLINE LEWIS

IT has already been remarked that, although both boy and girl babies at first wear petticoats, there is some slight difference in shape, as those for the boys are generally cut with long waists, the skirt part consisting of a shaped or straight-gathered frill. The little frocks, too, even the kilted style, could be made on the same lines.

Diagram **33** shows a set of boy-baby garments for the first stage: (*a*) is the small combination, consisting of two parts, the leg portions of which, made a little larger, will afterwards do for pants. At this very early stage, however, a little knitted vest, cut up sufficiently deep to form legs, will answer the purpose admirably. (*e*) is an American vest or shirt, made of very finest flannel, which may be worn up to four years of age under a tunic or suit.



33. BABY-BOY GARMENTS

The small drawers are shown at (*b*). These are made all in one, the fastening consisting of tape passed through eyelet-holes, as in the sketch, which are drawn up and passed round the buttons of the bodice. (*c*) is the petticoat, which differs only from that shown in **47** in having the seams from the armholes, and one instead of two shaped frills for the skirt.

The frock, made of white flannel, Viyella, or wincey, is shown in (*d*). (*g*) is a cross-over tunic, with vest and collar; (*h*), a pleated tunic frock. For quite small boys these are better arranged in a short yoke, but for older boys the pleats should come from the shoulder. (*i*) shows a smock, or overall, of holland or linen, and (*f*) a neat variation of the tunic suit, with an added waistcoat.

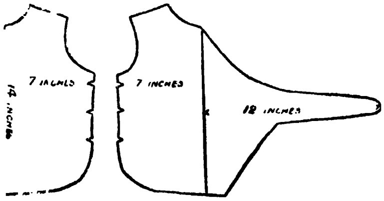
Tunic Suits. Nearly all these garments can be cut with the aid of the draftings already given, with slight alterations. The bodice of the petticoat and frock, for instance, is the same as in **25**, only a few inches being added to the length, and seams made to come from front of armhole. Directions have already been given in DRESSMAKING for cutting circular and shaped flounces, the little skirt sketched being of this shape, as it sets out so much better at the lower edge than the straight-cut one.

The little frock is exactly the same shape, minus the seams at side of front, the pleats being arranged on the pattern before cutting out. If made in washing material the bodice need not be lined, but the pleats should be stitched down at each edge; if of woollen goods, a lining is needed. The petticoat will take ½ yd. of 36-in. material, and the frock from 1 to 1½ yd. of 27-in. goods.

Diagram **34** shows the shape of the American shirt, which can also be adapted from the bodice pattern, with the necessary extension for the belt part. This vest should be cut selvedge ways of the flannel, as it is then much less likely to stretch. The edges are bound with lute ribbon, care being taken not to stretch the crossway edges, whilst the seams must be neatly herringboned with fine cotton. Three-quarters of a yard of flannel are required.

In **35** we have the drafting of a tunic which will serve for (*f*), (*g*), (*h*) and (*i*) in **33**, as well as for (*d*) and (*f*) in **36**. These can be evolved from **35** by adding on the requisite length and width to the lower portion. The plain tunic measures about 1¼ yd. round the lower edge.

The double broken line at (*a*) in **35** shows the direction to be taken for the fronts of the cross-over tunic in (*g*) of **33** for a very little boy; whilst the single row of broken lines indicate the direction for the plain double-breasted affair, with a diagonal closing, as in (*d*) of **36**.



34. AMERICAN SHIRT

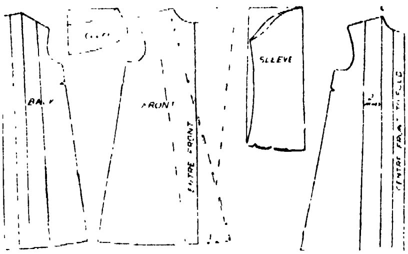
The pattern will also serve as model for the pleated tunic, shown in the same diagram [**33**], by modelling the pleats, as described for the pleated skirt, as shown in diagram **30**, and also in TAILORING FOR GIRLS [page 2468]. The box pleats are about 2 in. wide. If a yoke be needed, cut this from the upper part, as shown by the notches, and model the pleats for the lower part as described.

This tunic may fasten at centre-back or front, as preferred; if in front, the opening must be made to come under the middle pleat.

Directions for drafting the collar have already been given, whilst that for the crossover tunic of

33 must be shaped to fit the neck and front opening. The vest can be cut to the directions of the singlet shown in the boy's man-o'-war suit, in 41, with the addition of a collar, or not, as fancy may dictate.

Little Boys' Suits. The ideal suit for small boys, advocated by many doctors, is the kilt. This provides the necessary leg covering and gives freedom, whilst ensuring warmth to encourage a proper blood supply to the knee and leg. The kilt can be worn with either coat and waistcoat—the making of both of which have been already described [31]—or a sailor blouse.

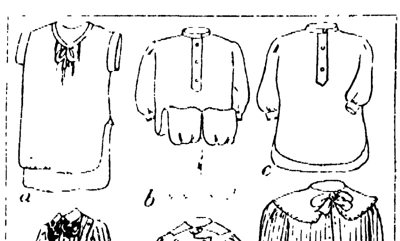


35. TUNIC

Diagram 36 shows the various garments suited to the second stage of the small boy's existence. (*c*) is the small first shirt, to be made of either flannel or shirting. Combinations would, however, still be retained, and knickers or pants would be the sam as those in 33, with a slight increase of size. (*b*) and (*a*) depict two French shapes for the small boy, which may be commended to the notice of mothers. The first is a cross between a chemise and a shirt, which may be recommended for summer, whilst the latter, combining the advantages of the shirt and combination, is advisable for winter wear. This latter shape, with the leg portion further lengthened, th sleeping-suit.

In (*d*) is shown a Russian tunic, which is worn over small knickers, and can be plain or pleated, as preferred. (*f*) depicts the same pattern, only made to fasten in the centre. This is a very suitable style for boys from four to six years of age.

Three things are necessary to this suit—*viz.*, the collar, tie, and the belt, whilst a fourth may also be added—the cap, which is of the "Tam" order, for outdoor wear. The suit may be made of any material, and any suitable colour. The suit can also be worn by older boys, when a plain Eton collar is best. The belt should be of leather, with a large plain buckle.



36. LITTLE BOY'S GARMENTS

In (*i*) we have a Scotch kilt suit. For the making of this, see directions for kilt in the previous course [page 4053]. It may, however, be remarked that the kilt should be fuller, and can well have three widths of material. (A kilt for an adult Scot measures, on an average, seven yards round.) If made with a plain front it should be made to lap over the full width of this plain part, and thus be double where required.

For the making of the coat and waistcoat, see Tailoring for Women and Children [page 1110], all that is necessary being to cut the pattern without allowing inlays, if required for the smaller size.

A Man-o'-War Suit. In (*g*) we have the suit cut exactly on the lines of that of a Jack Tar. From a hygienic point of view this is by far the best sailor style for the tiny boy, because the blouse, or "jumper," as it is technically known, is cut somewhat long, so as to be tucked into the waist part of the trousers, which are cut with a fall-front, and thus affords more warmth than the ordinary blouse gathered into an elastic.

(*e*) shows a blouse fastened over in the manner of a short Breton coat, which makes a warm wrap. In the American fashion it fastens over in the opposite direction. (*h*) illustrates a removable sailor collar, the semi-circular piece at the back keeping this in position. From six years of age and onwards the coat and knickers, as well as the Norfolk and other suits which are described in Tailoring [page 1752], can be worn. With regard to his out-of-door attire, the small boy looks very well in a tunic coat, cut on similar lines to that sketched in 36, made of cloth, velveteen, or corduroy velvet, with leather belt and large square buckle. Another style would be the sacque coat, cut the same as in 32, only less full in the skirt portion, and made single or double-breasted, as preferred. This can be accompanied by two or three graduated capes, highwayman fashion, and a tricorn hat.

The reefer coat is a very suitable accompaniment to the man-o'-war suit shown in 36.

Later on the little boy may quite well be clad in an overcoat with a step-collar, with Chesterfield or double-breasted fronts, for which full description as to drafting and making are given in Boys' Suits [page 1754]. The system of drafting there given will answer for this with the necessary alterations of chest and length measure. In many cases the drafting will do perfectly for the smaller size, if cut without allowing inlays. The making of such an overcoat will be exactly the same as for the larger size. If required double-breasted, and to fasten with buttons and buttonholes instead of a fly-front, an extra two inches must be allowed for the lap-over, whilst the fronts would be made as described for the Norfolk coat.

Continued

ARMY
continued from page 4032

AN ARMY COMMISSION

Entrance Examination and Conditions. Cadetship. Promotion. Emoluments and Expenses. The Indian and Egyptian Services

By C. DUNCAN CROSS

WE have seen how a man may rise from private to warrant rank. We now come to the career of a soldier who joins the Service as an officer.

To be eligible, the young man must attain to certain physical requirements. His chest measurement and height must accord with the figures given in the following table; his eyesight must be good, and his hearing perfect. His teeth are carefully examined. More than ten lost or decayed will disqualify him, though a decayed tooth well stopped is counted as sound.

Age last birthday.	Height without shoes.	Chest.	
		Girth when fully expanded.	Range of Expansion.
18	62 and under 65	34½	2
	65 ,, 68	35	2
	68 ,, 72	35½	2
	72 and upwards	36	2½
19	62½ and under 65	35	2
	65 ,, 68	35	2
	68 ,, 70	35½	2
	70 ,, 72	36	2
	72 and upwards	36½	2½

He will choose first of all which of the two great divisions of the Army he desires to enter. If he has a strong taste for engineering, for mathematics, and for the applied sciences, he will do well to choose the Royal Engineers or the Royal Artillery, through the Royal Military Academy. Or, if he prefer, he will enter the Cavalry, the Infantry, or the Army Service Corps, through the Royal Military College, Sandhurst.

The Royal Military Academy. We shall consider first the Royal Military Academy, or, as it is called, "the Shop."

Admission is gained by open competitive examination (fee, £2 in London, £3 in Dublin), held in June and November each year. The candidate must be between 18 and 19½ years of age. He must produce either a leaving certificate from one of the accepted sources, such as the Oxford and Cambridge Schools Examination Board, the Universities of London or Birmingham, the Oxford or Cambridge Local Examination Board (in Scotland the Scottish Education Department, and in Wales the Central Welsh Board for Intermediate Education), or he must produce a "qualifying" certificate, for which he is examined by an Army qualifying board in English, English history and geography, elementary mathematics, and two out of the following three subjects: Science; French or German; Latin or Greek. Or he can produce an "exempting" certificate showing that he has passed certain other Civil Service examinations of an equal or greater severity.

The subjects of the entrance examination are as follow:

COMPULSORY SUBJECTS

ENGLISH. Essay, précis writing, and reproduction of passages read.

FRENCH OR GERMAN. Translation into and from, conversation, and an essay.

MATHEMATICS I. Arithmetic, geometry, Euclid I. to VI., algebra, a knowledge of simple trigonometry, simple statics and dynamics.

And two of the following:

OPTIONAL SUBJECTS

MATHEMATICS II. Including mathematics I. (above), with solid geometry, Euclid (Book XI.), advanced algebra, differential and integral calculus, co-ordinate geometry, elementary statics of liquids and gases.

HISTORY. A general paper, a period or a general paper on ancient history, a military biography.

GERMAN OR FRENCH. Other than the language selected in compulsory subjects.

LATIN OR GREEK. Translation into and from, Latin verse or Roman literature.

SCIENCE. An examination to test a general knowledge of physics and chemistry.

Physical Standard. Should the applicant prove successful in the examination, it will be necessary for him to pass a severe medical test before he can be accepted. To minimise the possibility of failure now, with its consequent waste of time and money, he may apply to the Secretary, War Office, for a preliminary medical examination (fee, £2 2s.), in which case arrangements will be made with a medical board at the military station nearest to the applicant's residence. This preliminary examination is in no way final, and binds the War Office neither to take nor reject the candidate, the final examination being the report on which his physical condition is considered. Should the final medical examination be unsatisfactory, an appeal may be made for a further inquiry into the applicant's health, in which case a fee of £4 4s. must be deposited in advance. This will be returned should the appeal be found to be justified.

Cadetship. The medical board safely passed, the candidate is then entered as a cadet. The fees range from £40 to £80 for the sons of officers, retired officers, and a few privileged persons, according to the rank of the father; for the son of a private gentleman the fee is £150. A few King's cadets (sons of officers who have died on service) are educated free of charge. Beyond this, for other than King's cadets, at the beginning of the course a sum of £35 must be paid for uniform, books, etc., and again at the beginning of the third term a further sum of £15.

An allowance of 3s. a day is made to each cadet in aid of expenses of uniform, messing, washing, etc., but a further allowance from the

parent is necessary. With economy on the part of the cadet, £50 a year will suffice for pocket-money, travelling and other expenses.

The course of instruction extends over two years, divided into four terms, and includes the following subjects:

Mathematics and mechanics, artillery, military engineering, practical geometry, military topography and freehand drawing, military history and tactics, electricity and magnetism, chemistry and physics, French and German, military law and interior economy, infantry drill, riding, gymnastics, signalling, workshops.

Every half-year the cadet is examined by the staff of the Academy, and by outside examiners at the end of each year. A certain percentage of marks must be gained or the cadet loses the term and forfeits all claim to choice of corps, and, if the same thing should happen again he is removed from the Academy.

A Commission. At the end of two years, supposing him to have reached the Fourth Class and passed his final examination successfully, the cadet is gazetted to a second lieutenant's commission in the Artillery or the Engineers.

The Royal Military College (Sandhurst) is an institution similar in character to "the Shop." Its function is the training of officers for the cavalry, the infantry, and the Army Service Corps. The qualifications and certificates are the same as those necessary for the Academy and the course consists of four terms normally, though, pending the enlargement of the college, a temporary two-term course has been adopted. The course is less strenuous than that of the Military Academy, gunnery, chemistry and physics, and workshop practice being omitted, and the cadets go into camp for three weeks in the summer.

Passing Out. When the final examination is passed and the candidate passes out of the Academy, the choice of corps, so far as vacancies permit, is given to those who have passed out highest in the order of merit at the final examination; but those candidates who are recommended for the Royal Artillery are given the opportunity of choosing whether they prefer the Field Artillery or the Garrison Artillery. Provided he has distinguished himself in riding, horsemanship, and Field Artillery drills, the cadet who desires it will be posted to the Field Artillery, from whose ranks are selected the best riders and the smartest officers for the Horse Artillery.

In passing from the Military College, selection is made among the successful candidates as follows. The cavalry cadets are appointed to British cavalry, and after their claims have been satisfied, the remaining commissions are thrown open to other cadets who desire them, and are allotted in order of merit. As to the infantry, cadets having special or territorial connection with certain regiments should apply before the examination to the Military Secretary through the commandant of the College. Occasionally, if the claim is a very strong one and no vacancy exists, the cadet is allowed to wait, but in no case may he wait more than six months. Candidates without special claims may apply for special regiments, but they are not allowed to wait should there be no vacancy. In due course the successful candidate's name appears in the "Gazette," he receives from the Military Secretary a confirmation by letter, and from the Adjutant-General orders to join his battalion.

The case of a cadet joining the Indian Army is treated separately.

University Men. A certain number of commissions are given to students at the great universities who are between the ages of twenty and twenty-five and who have graduated in any of the approved subjects (except theology, medicine, music, or commerce). A student passing with first-class honours is entitled to count one year's seniority for it. A candidate for the Royal Artillery must show that he has qualified in the same mathematical subjects as are required in the entrance examination for the Royal Military Academy. The further qualifications required of all university students are that they shall have been attached for training to a Regular unit during the previous two years, and that they can obtain qualifying marks (·5 in the aggregate) in military history and strategy, tactics, military engineering and topography, military law, and military administration.

DAILY RATE OF REGIMENTAL PAY - OFFICERS

	Cavalry.		Artillery.		Royal Engineers.*	Infantry.		R.A.M.C.
	Household Cavalry.	Cavalry of the Line.	Royal Horse Artillery.	Royal Field or Garrison Artillery.		Guards.†	Line and A.S.C.¶	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Colonel or Lieut.-Colonel	1 3 6	1 1 6	1 4 9	0 18 0	0 18 0	0 18 0	0 18 0	2 0 0
Major	0 15 6	0 15 0	0 18 6	0 16 0	0 16 0	0 13 7	0 13 7	1 3 6
,, After 2 years' service ..	0 18 0	0 17 0	—	—	—	0 16 0	0 16 0	—
Captain	0 13 6	0 13 0	0 15 0	0 11 7	0 11 7	0 11 7	0 11 7	0 15 6
,, With Brevet rank	0 15 6	0 15 0	0 17 0	0 13 7	0 13 7	0 13 7	0 13 7	—
Lieutenant	0 9 0	0 7 8	0 8 10	0 6 10	0 6 10	0 6 6	0 6 6	0 14 0
Second Lieutenant	0 6 8	0 6 8	0 7 8	0 5 7	0 5 7	0 5 3	0 5 3	—
Adjutant, if Captain, additional ..	0 3 6	0 5 0	0 2 6	0 2 6	—	0 2 6	0 2 6	—
,, if Lieutenant ,, ..	0 2 6	0 5 0	0 2 6	0 2 6	—	0 3 6	0 3 6	—
‡ Quartermaster	0 10 6	0 10 6	0 10 6	0 9 6	0 9 6	0 9 0	0 9 0	0 9 0
Ridingmaster	0 10 6	0 10 6	0 10 6	0 10 0	0 10 6	—	—	—

* In addition, "Engineers' Pay," Lt.-Col., 14s.; Major, 9s.; Capt., 6s.; Lieut. and Second Lieut., 4s. a day.

† In addition, "Guards' Pay," Col., £250; Lt.-Col., £200; Major, £170; Capt., £140; Lieut. and Second Lieut., £70 a year.

‡ Rising 1s. 6d. a day for every five years served.

¶ In addition, A.S.C. "Corps Pay," Lt.-Col., 6s.; Major, 5s. 4d.; Capt., 4s.; Lieut., 3s. 6d.; Second Lieut., 2s 6d. a day.

Officers of the Militia and the Imperial Yeomanry are also admitted on similar conditions, provided they have served for two annual trainings, have been attached to a Regular unit for instruction in drill, discipline, interior economy, musketry, signalling, and practical tactics, and are recommended by their commanding officers. Further, they must produce the "leaving" or qualifying certificate before mentioned.

Equipment. The cost to a newly appointed lieutenant, including private clothes, etc., in a Line regiment of infantry will be not far short of £100, and in the cavalry close upon £250. The equipment, such as revolver, field-glasses, saddlery, etc., can be bought either at Government price from the Ordnance Department, or privately. In the Foot Guards and Household Cavalry the outlay is naturally greater. It may be said that a second lieutenant in the Infantry of the Line should have at least £100 and in the cavalry £200 a year of his own. Even this will mean cutting down personal expenses to a minimum.

Promotion. As second lieutenant he must, before promotion to lieutenant, pass a simple professional examination in regimental duties, which is based on the "King's Regulations," the Army books and forms in use, the Pay Warrant, "Equipment Regulations," and, in the case of foreign service, on the special Army Regulations laid down for the particular country in which he is serving. The examination divides itself into four heads:

1. Discipline. General instructions; administration; courts of inquiry; deserters; and disposal of prisoners.
2. Duties. Roster of duties; garrison and field duties; compliments; guards and sentries; military funerals; duties in aid of civil authorities.
3. Interior Economy. Officers and N.C.O.'s; system of keeping accounts, books, and returns for squadron, battery, or company; system of payment, messing, and supply of necessaries for same; pay of N.C.O.'s and transfer and discharge of soldiers.
4. Miscellaneous Information. The method of supplying troops in quarters and in the field; a junior officer's duties in connection with the movement of troops by land and sea; detail of carrying arms and equipment (for the cavalry, the detail of saddlery, the fitting of saddle and bridle, etc.).

Practical Test. In addition, there is a practical examination in the field to be passed. The candidate is required, in addition to giving the words of command, to explain clearly and simply the movement he orders to be performed. In the cavalry, the examination is based on "Cavalry Training" and the "Musketry Regulations," and comprises a knowledge of

Drills. Military equitation; the instruction of a soldier mounted and on foot; and the capacity to command a squadron on parade or in the field.

Musketry. Instruction of the recruit; preliminary drill and practice; field firing and dismounted practice with horses; musketry returns.

Miscellaneous subjects from "Cavalry Training."

Artillery. In the Artillery the examination is rather more complicated. The range of books required is also wider. It includes "Cavalry Training," "Field Artillery Training," "Rifle Exercises and Infantry Training," "Infantry Training," and the "Handbook of the Gun," "Instruction for Practice, Horse, Field, and Mountain Artillery."

Here is the syllabus of the examination:

Drills and Exercises. Instruction of dismounted men; equitation, stable duties, and driving; drills, manœuvres, and ceremonial observances; rifle and pistol exercise; guards; section gun drill; gun-laying—sights, tangent, and telescopic; indirect laying and the use of the clinometer; care and adjustment of sights; the laying of a gun under competition conditions.

Equipment. Taking to pieces fittings of guns and carriages, and the explanation of their uses; a knowledge of the parts of gun-carriages likely to suffer from wear, ill-usage, or service conditions; explanation of the construction and action of various projectiles; the action of fuses; preparation charges and the setting of the fuse.

Practice. A general knowledge of Chapter IV. of "Field Artillery Training."

The examination for coast defence companies is similar, but deals more with the work of a coast defence section of artillery—the construction of heavy guns, their fitting and adjustment, and so forth. The books on which the examination is based are "Infantry Training," parts I. and II.; "Handbook of the Gun"; "Garrison Artillery Training," Vols. I., II., and III.; and "Instruction for Practice Seawards."

For siege companies and heavy batteries the examination is much the same as for coast defence companies, but in relation to siege guns particularly. The books required are "Infantry Training," "Siege Artillery Drill," and "Heavy Artillery Training."

Engineers and Infantry. For engineers and infantry the examination is quite simple, and is based on "Infantry Training," "Combined Training," and the "Musketry Regulations." The following are the subjects:

Drill. Squad and company drill; to command a company in battalion drill.

Exercises. Rifle and firing exercises; advanced guards and rear guards; outposts and skirmishing; the company in attack and defence; ceremonial.

Musketry. Instruction of the recruit; preliminary drill and practice; the making up of drill and practice returns.

The Army Service Corps examination is practically the same as that for infantry and engineers, except that under the heading of "Drills" comes knowledge of corps duties from "A.S.C. Training," and instead of "Exercises" is carbine exercise and manual and firing exercises.

Promotion to Captain. The next stage in the lieutenant's career is promotion to captain. This comes by seniority, with a certain amount of selection in the case of a particularly desirable officer. It is possible to prepare for this, but more usually a tutor is employed for a month at a cost of twelve to fourteen guineas. In any case, he must pass a searching test in (i.) Practical military topography; (ii.) practical military engineering; (iii.) practical tactics; (iv.) riding; and, if he belong to a mounted branch, (v.) horsemastership, which includes horsebreaking, veterinary knowledge, and, indeed, a comprehensive knowledge of the whole subject. Beyond this lies a theoretical acquaintance with military law,

engineering, tactics and topography, administration, organisation and equipment, and military history. A candidate for a captaincy in the artillery must in addition pass in artillery, and in the A.S.C. will be tested in the varied duties which fall to the officers of that branch.

Higher Staff Appointments. As captain he will, if he be an ambitious man, try to enter the Staff College, which, after a two-years' course, will make him eligible for higher staff appointments. There is also the recently created general staff which will attract the most brilliant soldier to its ranks. To prepare for the entrance examination a tutor (cost about £40) is necessary. On the other hand, he may prefer to remain with his regiment, in which case seniority will carry him to senior major. Before promotion to lieutenant-colonel he will have to show in the field his ability to handle mixed forces of all arms of the Service which will be placed under his command, to take part in staff rides and war games, and generally to prove by practical demonstration that he can not only command men, but that he has also those higher qualities which make the successful tactician and strategist.

Among the side avenues of the Army the Royal Army Medical Corps, the Veterinary Service Corps, the religious, and the scholastic branches offer many advantages to men of special training. As these are of purely technical interest, and appeal only to men with special civilian training they may be dismissed with the statement that to enter them a proof of professional capability is required in the form of a diploma, and that promotion comes by seniority and length of service.

The Indian Army. On passing out of the Military College the cadet is gazetted as second lieutenant on the unattached list, and is appointed to a British regiment serving in India. From the date of his first commission to the date of his arrival in India he receives the British pay of his rank. At the expiration of one year's actual duty with the British regiment, should he prove satisfactory, he is admitted to the Indian Army with the rank of second lieutenant, and appointed to a native regiment. Here his position is infinitely more responsible than that of second lieutenant in the British Service. He has native officers of many years' service under him, and his pay—considering the cheapness of native servants, and the lower standard of expense generally obtaining in the Indian Service—is more adequate. Within two years and three months from his first commission he must pass an examination in Urdu by the lower standard, and he will then be promoted to lieutenant. Within three years of his admission to the Indian Army he must pass the higher standard of Urdu, for until that is done he is not eligible for any higher appointment than squadron or double company officer. When the direct supply of officers from Sandhurst fails, officers are drawn direct from volunteers from British regiments.

In addition to the Urdu examination, officers are required to pass another examination in the language chiefly spoken by the men of their regiments. There is also a simple professional examination.

Promotion. Promotion in the Indian Army (subject to the passing the examination) is regulated by length of service. As we have seen, after 27 months a second lieutenant is promoted to lieutenant; after nine years he becomes a captain; after 18 years, a major; and after 26 years a lieutenant-colonel. It may, however, be accelerated with luck by a brilliant man. A major may be promoted to lieutenant-colonel when he is appointed to command a regiment or battalion, or an appointment which would carry the substantive rank of colonel if the officer were qualified for that rank; and in one or two other cases.

A lieutenant-colonel reaches the rank of colonel in similar fashion on completion of three years' service in command of a battalion or regiment, on completion of six years' service as brevet lieutenant-colonel in a military appointment, or by holding certain analogous positions.

Promotion to the rank of major-general is made by selection. In the same fashion is promotion to one of the five lieutenant-generalships. Last of all, above this come the three generalships by seniority after three years or more as lieutenant-general.

The Egyptian Army. Officers of the British Army desirous of joining the Egyptian Army must apply through their colonel to the Adjutant-General of the Egyptian Army, Khartoum. Officers must be over 25 years of age, unmarried, must be good horsemen, and must obtain a medical certificate that their health is equal to service in a tropical climate. They must have had five years as commissioned officers, and must have passed for the rank higher than that which they hold.

On acceptance they join the Army as bimbashis (majors), or a higher rank if their position in the British Service warrants it. After three months' probation with a native regiment their pay is at the rate of £540 a year. They then sign an agreement for two years, during which time they learn Arabic and the vernacular spoken by their command. The agreement on expiration may be extended by two years, later by three years, and again by three years up to 10 years, by which time the rank of kaimakam (colonel) will have been reached with salaries of £720 a year.

For men who can stand the strain of the climate, and who are willing to cut themselves off from home and friends, the Indian and Egyptian Armies offer exceptional chances both in the good rate of pay and the opportunities of civil and staff appointments to which they lead.

Army concluded; followed by
NAVY

MACHINE DESIGN

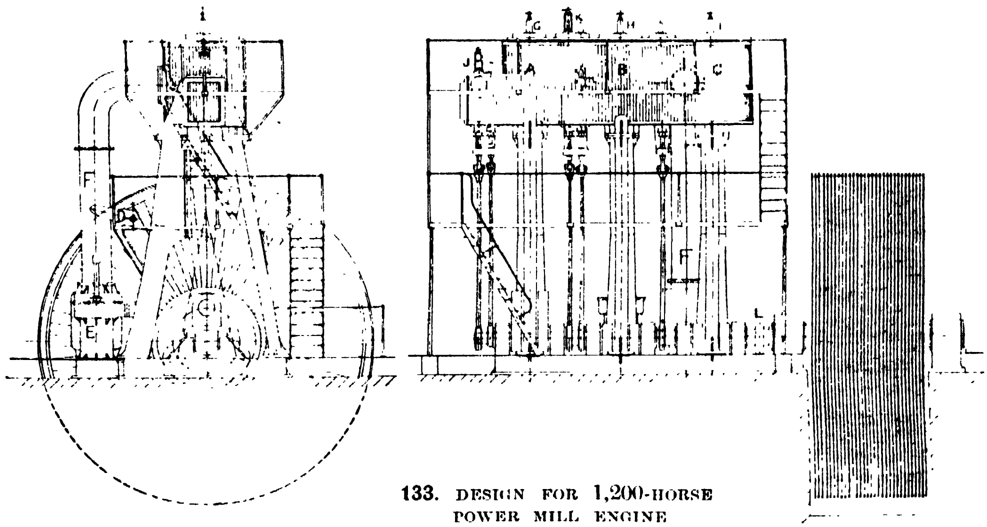
Design Drawings. General Drawings. Frames for Vertical and Horizontal Engines. Machine Tool Frames. Crane Frames

By JOSEPH W. HORNER

Design Drawings. We give in this lesson a series of drawings illustrating the art of machine design. Fig. **133** is a design drawing of a 1,200-horse power mill engine. It is a typical example of the class of drawing usually made to accompany a tender, for no attempt is made to show details or sectional views, the object aimed at being to produce an attractive-looking drawing made to scale, and from which the over-all dimensions may be taken. In actual practice such a drawing is set out by an experienced draughtsman; but the student has much to gain by copying it and studying the proportions and positions of the various parts, for it is from such design drawings that the working, or detail, drawings are deduced. Foremost will be noticed the rope wheel, with its 30 grooves for the driving ropes [see page 3428 for section of groove], and the opening cut in the ground for the reception of the wheel. It is necessary to provide a bearing for the shaft on the outside of the wheel in order to avoid the tremendous load which would otherwise come on the shaft, due to the overhang of the wheel. There are three cylinders, A, B, and C, supported upon front and back columns from the bedplate; the front columns are circular, but the back ones are shaped to carry the crosshead guides, and are cast in hollow rectangular section. The upper ends of the columns have flanges cast on to meet the feet of the cylinders. The lower ends are splayed out in order to clear the connecting-rod heads, and have flanges to meet facings on the bedplate.

The lever D is for working the air-pump E. It receives motion from one of the piston-rod crossheads, and is pivoted on a bracket bolted to one of the back columns. The air-pump itself is bolted to the bedplate, and also to the column. The air-pump is connected with the low-pressure cylinder C by the pipe F, and its function is to maintain a vacuum for that cylinder to exhaust into. A note on air-pump levers will be found on page 828 in MECHANICAL ENGINEERING.

The outline of the cylinders themselves does not appear, as they are surrounded with lagging strips. *Lagging* consists of wrapping the cylinder with asbestos mattresses, or similar non-conducting material, in order to prevent loss of heat, the mattresses being kept in place by strips of wood and brass bands, or alternatively by thin sheets of steel. The valve-chests are similarly lagged. Relief valves, G, H, I, are shown on the cylinder covers, and also upon the high pressure and intermediate valve-chest covers J and K. The relative positions of the cranks are seen in the end elevation, and are projected in the side elevation. A bearing is arranged upon each side of each crank, and a solid forged coupling, L, connects the crank-shaft to the pulley-shaft. The working floor level is raised above the foundation line, so as to give easy access to the bearings and cranks. Two platforms are built around the engine at suitable levels to facilitate attention to the working parts, the upper platform serving for the cylinder and valve covers, etc., while the lower platform is for

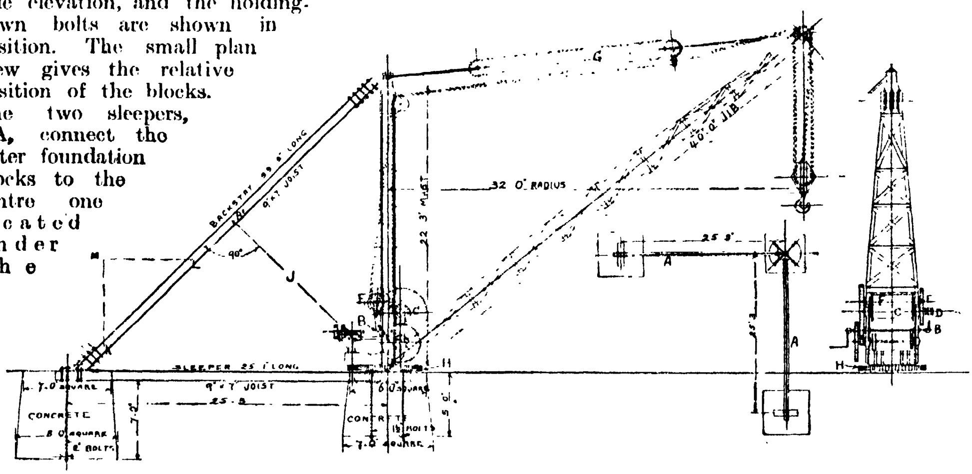


133. DESIGN FOR 1,200-HORSE POWER MILL ENGINE

VERTICAL ENGINE FRAMES							
Cylinders.		A	B	C	D	E	F
Bore.	Stroke						
6	9	4 0	1 3	1 0	$5\frac{1}{2}$	$1\frac{1}{4}$	$\frac{5}{8}$
10	13	5 3	1 4	1 0	$6\frac{1}{2}$	$1\frac{3}{4}$	$\frac{3}{4}$
12	16	6 6	1 5	1 1	$7\frac{1}{2}$	2	$\frac{7}{8}$
14	18	7 3	1 6	1 $1\frac{1}{2}$	$8\frac{1}{2}$	$2\frac{1}{8}$	1
16	24	8 0	1 8	1 2	$9\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{1}{4}$
18	24	8 0	2 0	1 6	10	$2\frac{1}{2}$	$1\frac{1}{4}$

the glands and bottom covers. Ladders and handrails are provided as shown in drawing.

General Drawings. Another class of drawing is shown in **134**, which is very similar to the preceding example, but presents much more detail. It is a *general arrangement drawing*, made after the details have been worked out on separate sheets, and it serves as a guide for the complete assembly and erection of the machine. The foundation blocks are fully dimensioned in the side elevation, and the holding-down bolts are shown in position. The small plan view gives the relative position of the blocks. The two sleepers, **AA,** connect the outer foundation blocks to the centre one located under the crane-mast; such a foundation is substantial and permanent, but very frequently, however, this type of crane has only temporary foundations, such as timber seatings and weights simply laid across the ends of the sleepers. The mast is furnished with top and bottom pivot pins, and the back stays support the top pivot. The crane gearing is seen in position at the lower end of the mast; there is a train of spur gear from the handle shaft B, connecting to the barrel C, which coils the hoisting-chain. A clutch, D, and gears, E, couple the hoisting barrel C to the barrel F, upon which is coiled another chain, which varies the radius of the jib by altering the length of the ties G, this movement being termed *derricking*, or *luffing*, the jib. The revolving, or slewing gear is arranged behind the mast and consists of spur and bevel gear, connecting to the curb ring H, which is bolted to the bedplate underneath the mast.



134. GENERAL ARRANGEMENT OF 15-TON DERRICK CRANE

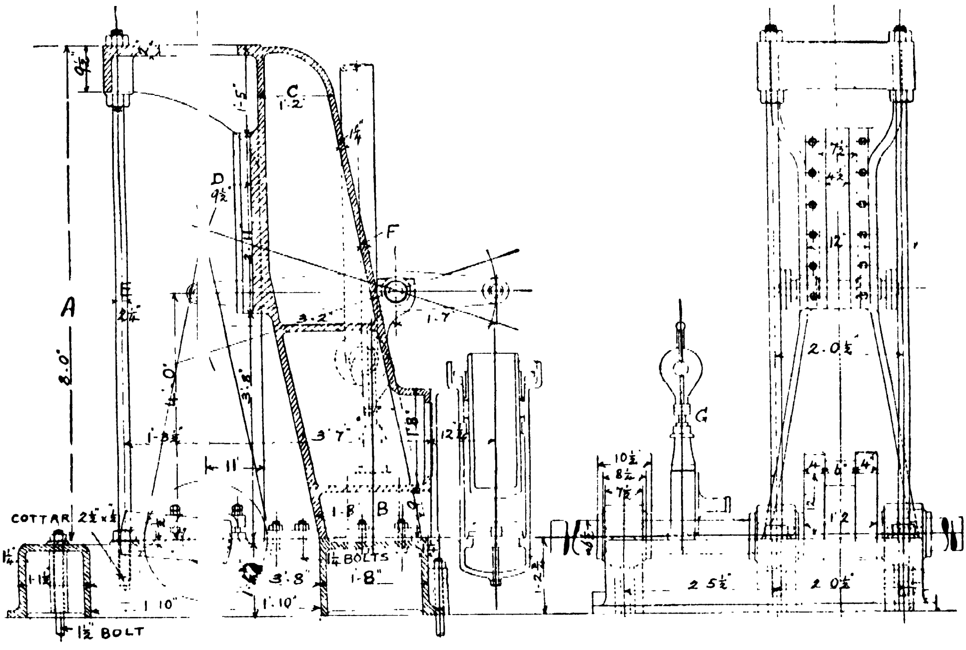
Detail Drawings. The drawings from which machines are actually manufactured are termed *detail drawings*, each part of the machine being fully delineated and dimensioned upon one or more sheets. Castings have a sheet to themselves, forgings have a separate sheet, plating another, and so forth, the object being to provide each work's department with drawings that concern the department alone. The principal detail drawing is the one which depicts the main framework of the machine. Framings are made of various metals and in various forms. Machine tools and engines are invariably built with cast-iron frames, although exceptions are to be found, the chief virtue in such frames being rigidity, a factor that cannot be calculated in anything like an exact manner. There is perhaps no other part that requires so much sound judgment and experience in order to produce satisfactory results. The earlier designers of engine frames, etc., aspired to architectural outlines and ornamentations; but increasing steam pressures, greater outputs, and closer economy, have resulted in the adoption of scientific lines of construction. Smooth outlines, easy curves, and even disposition of metal are now aimed at. The same may be said of machine tools generally. Other frames, such as cranes and overhead travellers, are built of mild steel; and, although experience is necessary in order

HORIZONTAL ENGINE FRAMES						
Cylinders.		A	B	C	D	E
Bore.	Stroke.					
8	12	5 6	1 9	1 2	9	$\frac{3}{4}$
10	14	6 3	2 3	1 5	11	$\frac{3}{4}$
12	16	7 0	2 6	1 8	12	$\frac{3}{4}$
14	18	8 0	3 0	1 10	13	$\frac{7}{8}$
16	24	8 9	3 4	2 0	15	1
18	24	9 0	3 6	2 3	17	$1\frac{1}{8}$

to design them, their proportions can be definitely calculated by estimating stresses, etc.

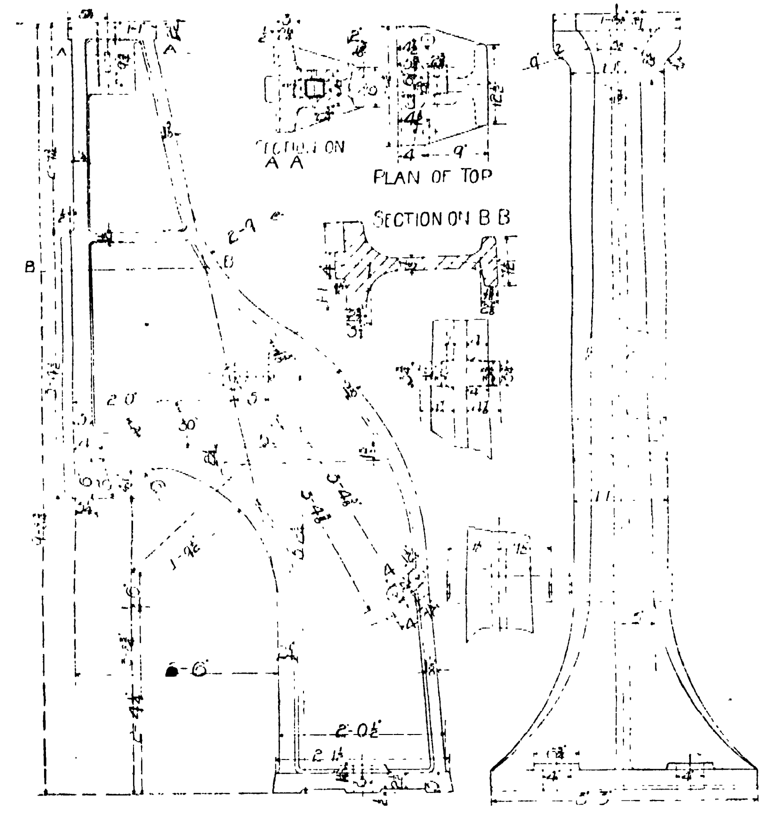
Vertical Engine Frame. Two views taken from a *detail drawinj* of a vertical engine frame are given in **135**; the construction is similar to **133**, but is for a smaller engine. The front supporting columns are of mild steel, and are cottared into a boss cast on the bedplate. The back column is shown in section, as well as in face elevation, the bearings for the air-pump lever and the bracket for the air-pump itself being shown in position. A table is given on page 4202 of the approximate leading dimensions of this class of engine frame, which will be useful to the student. There are many variations in the outlines and sections of such frames; they are also made for single, doub'e, triple, and quadruple cylinders. When large engines are to be built, it is usual to replace the front columns by rectangular castings similar to the back ones, double slides being thus provided for the cross-head, but the chief reason for the modification is to provide better and more substantial supports for the heavy cylinders above. The engine shown [**135**] has provision for the governor G, and an extended bedplate with outer bearing for a belt drive; the cylinder is 16 in. in diameter by 24 in. stroke.

Horizontal Engine Frame. Fig. 138 illustrates a *detail drawing* of a pair of frames for a horizontal compound engine. Each frame consists of a single member, rectangular in section and of cast iron; the guides are formed in the same casting, and are cylindrical, having openings on each side. The left hand frame is for the high pressure cylinder, and the right hand for the low pressure, each cylinder being supported from foundations, as well as being held by the ends of the guides. The main bearings are formed in the frame in a similar manner as they are formed in the bedplate of the previous example. It is usual to detail the bearings separately. The piston-rod glands are arranged in the ends of the guides, but they are also frequently made part of the cylinder casting. Bosses are formed for the foundation bolts, and extend the full depth of the framework, wherever they occur; the centre bosses are provided with ribs connecting them to the side walls. Bolt bosses are also made on the end of the frames for coupling up to the cylinders. The guides have facings top and bottom, bored out for the cross-head to bear against. We give a table of approximate over-all dimensions for this class of frame on page 4202, but it will be understood that many variations occur with different manufacturers.



135. FRAME FOR A VERTICAL ENGINE

Steam Hammer Frame. A *detail drawing* of a frame for a steam hammer is given in **136**. The views presented comprise a side elevation, a back elevation, a plan of the top, two sections, and separate details of bosses. The head of the frame is arranged to receive a square bolt, which is cottared in place; the upper end of the bolt passes through the foot of the hammer cylinder, as well as the two outer bolts, and holds it down with a nut in the usual way; there are two such frames, one on each side of the hammer block. The section of the frame is different to the preceding engine frames, it being what is termed H section instead of a hollow rectangle; the inner flange throughout is heavier than the outer one, it being subjected to severe compressive shocks; three cross ribs are arranged to tie the flanges together, and to stiffen

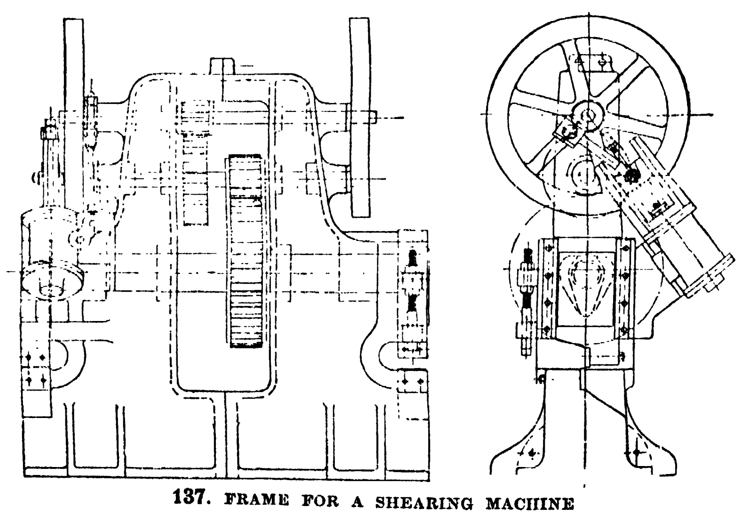


136. FRAME FOR A 25-CWT. STEAM HAMMER

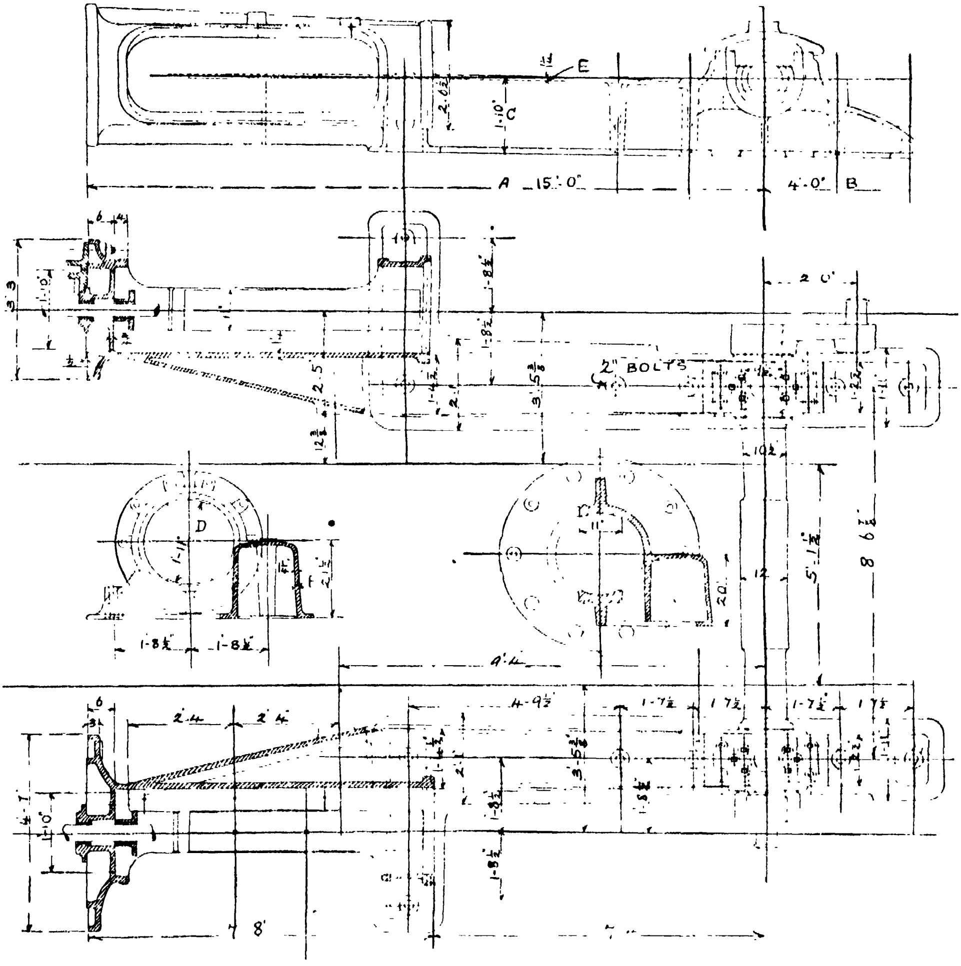
the web plate The taper allowed on the flanges is considerable, and large radii are put in the corners. This is done in order to ensure a sound casting, free from initial stress due to contraction, and also to enable the pattern to be drawn easily from the mould, and so produce a smooth outline. The front of the frame at the bottom of the hammer guides is specially heavy, to prevent fracture at this point. The bosses are for the pivot pins of the working levers. The base of the frame is provided with facing strips and bosses for the foundation bolts, and the holes are slotted so as to permit adjustment endwise. The slope of the upper part of the frame is obtained by prolonging the line, as shown [136], until it forms a tangent with the inside radius of the lower part. The drawing is reproduced from an actual working drawing supplied by Messrs. Thwaites Bros., of Bradford, Yorkshire.

Machine Tool Frames. Outlines of machine tool frames will be found on pages 206 and 207 in MECHANICAL ENGINEERING, and further examples are given under MACHINE TOOLS. We amplify these by 137, which is a drawing of a bar shearing machine, driven by an engine carried upon the framework. The frame is in halves, bolted at top and bottom, and is in hollow form, with an opening at the centre for the gearing; bosses are cast on the upper part to carry the engine shaft, which is shown in position with the two fly-wheels. There are two spur-gear reductions from the eccentric shaft, which operates the moving cutter. The metal is massed around the jaw which receives the cutters, the top and bottom of the jaw having enormous strength to withstand the reaction of shearing without yielding. A bracket and facing are provided for the steam cylinder, which is 8 in. diameter by 12-in. stroke. The machine will shear up to 2-in. square bars on either side.

Mild Steel Frames. Mild steel frames are not used for machine tools proper on account of their elasticity and consequent



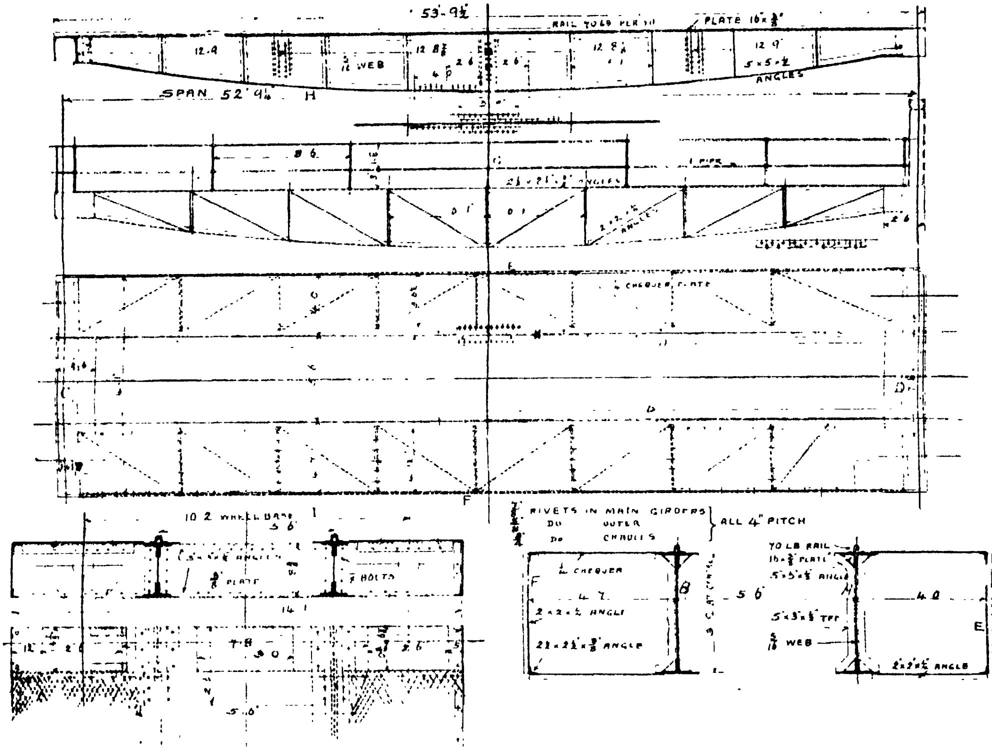
137. FRAME FOR A SHEARING MACHINE



138. FRAME FOR A HORIZONTAL ENGINE

lack of rigidity; they do, however, enter into the construction of many appliances used by engineers, and in such appliances have a far greater value than cast-iron frames. Locomotive frames, carriage frames, large crane frames, furnace charging machines, etc., are examples in which cast iron would be a failure. Fig. **139** illustrates the steel frame of an overhead traveller as used in most engineers' shops. It consists of a pair of girders, A and B, secured to two cradles, C and D, which are mounted upon double-flanged wheels. These wheels are set to run upon rails which are built on the side walls or columns of the shop. The girders A and B are provided with rails which form the track for a trolley or crab, which is fitted with hoisting mechanism and necessary tackle. The machine is driven electrically, a separate motor being applied to each movement. The example [**139**] is for a high-speed electric traveller, and it is therefore specially braced to meet the stresses due to inertia in starting and stopping. The auxiliary girders E and F are stayed to the main girders A and B by bracing bars on the lower boom in such a way as to afford them lateral support; the upper booms have chequer plates connecting them instead of bracing bars, and these incidentally form a platform for the attendant, and are protected by handrailing as shown at G. The distance from centre to centre of the main rails H is termed the span, and the distance apart centre to centre of the wheels I is the wheel base and is usually one-fifth of the span. The depth of the main girders at the centre of the span is generally one-fifteenth of the span.

The upper elevation shows the main girder with its joints. The web plate is made in four lengths for convenience, while the boom plates and angles are made in two lengths; the central joint is shown in plan. The next elevation is of the outer girder with the handrailing on top, the form of the bracing being known as the Linville and being economical of material.



139. FRAME FOR A 35-TON ELECTRIC TRAVELLER

The general plan view shows all the girders in position as well as the cradles and platform. The two bottom left-hand enlarged views are details of the cradles, while the right-hand bottom view is an enlarged section cut through the four girders at the centre.

Calculations. The main sections of the various members of such frames as **134** and **139** can be decided by calculations. In **134** the load on the jib and tie may be determined as described on page 415 of MECHANICAL ENGINEERING. The tie-rods and chains are tension members, and can have sufficient area allowed to permit a factor of safety of 8 to 1; the jib is a column and should have a factor of safety of 6 to 1. The load on the backstay is found by taking moments about I; the forward moment is made up of the load multiplied by the full radius plus the weight of the jib multiplied by half the radius; adding these two moments together and dividing by distance J, we get the load on the backstay (B1). The backstay may be either in compression or tension, according to the position of the jib in plan; as it is weakest in compression it may be proportioned as a column with a factor of safety of 6 to 1. The load on the sleeper and the mast is easily obtained by a simple diagram. Mark off the load on the backstay as K L on a scale of tons, and draw a vertical line from K till it cuts a horizontal line from L, meeting at M, then K M scales the load on the mast and L M scales the load on the sleeper. Both mast and sleeper have alternatively tensile and compressive loads in a similar manner to the backstay, and they are proportioned for compression; the mast has to sustain in addition the load due to the hoisting and derricking chains, which also impose compressive loads.

Traveller Frame. In **139** we have the simple case of loaded beams or girders fully dealt with on page 540 in MECHANICAL ENGINEERING and page 1984 in MATERIALS AND STRUCTURES. The load on the main girders is made up from the actual load lifted by the traveller plus the weight of the movable crab and half the weight of the girders themselves. The cradles may be regarded as beams of a length equal to the wheel base, and loaded at the two points at which the main girders are built in; each cradle has to sustain half the weight of the whole framework plus nearly the whole weight of the crab and load; the exact amount of this latter sum depends upon the nearness of the extreme position of the crab to the cradle. The outer girders have to sustain their own weight and half the weight of the platform, etc. When long spans are involved the main girders as well as the outer girders are often designed as Warren or Linville braced members.

Continued

Continued from page 4046

PLANE GEOMETRY

Abbreviations used in Geometry. Definitions. Axioms. Postulates. Prob'ems and Theorems. Corollaries

By HERBERT J. ALLPORT, M.A.

List of Abbreviations Used

$\angle$	angle	$\parallel$	parallel
Δ	triangle	$\perp$	perpendicular
▱	parallelogram	$>$	is greater than
$\odot$	circle	$<$	is less than
$\bigcirc^{ce}$	circumference	hyp.	hypothesis
$\therefore$	therefore		

Definitions. 1. A limited portion of space is called a *solid*. A solid has three *dimensions*—*viz.*, length, breadth and thickness.

The amount of space occupied by a solid is called its *volume*.

2. The *surface* of a body separates it from the surrounding space. A surface has no thickness. It is therefore of two dimensions, length and breadth.

3. The intersections of surfaces are called *lines*. Since surfaces have no thickness, it is evident that their intersections can have neither breadth nor thickness. Hence a line has only one dimension, length.

4. The extremities of a line are *points*. Also, the intersections of lines are points. Points have neither length, breadth nor thickness. Thus, points have no dimensions.

It follows, then, that we can only *represent* a point. If we make a dot with a pencil, the dot will have *some* length and breadth, however sharp the pencil may be. In the same way, we cannot draw a geometrical line, but if we move the pencil point over the paper, the mark left will *represent* a line.

5. Lines may be *straight* or *curved*.

A *straight* line is traced by a point which moves so as to keep always the *same direction*.

A *curved* line is traced by a point whose direction of motion continually changes.

From the definition of a straight line we have the following *Axioms*, or self-evident truths:

(i.) *The shortest distance between two points is the straight line which joins them.*

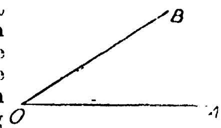
(ii.) *Two straight lines cannot enclose a space.*

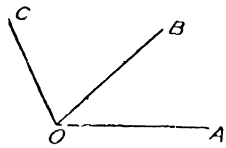
6. Surfaces may be *plane* or *curved*.

A *plane surface*, or, as it is generally called, a *plane*, is a *flat* surface. The flatness is tested by taking any two points in the surface and joining them by a straight line. If the surface is flat, the straight line will lie on the surface. Notice that we must be able to take *any* two points; it must not be possible to find two points on the surface such that the straight line between them does *not* lie on the surface.

7. When two straight lines meet at a point they are said to form an *angle*. The point is called the *vertex* of the angle, and the straight lines are called the *arms*.

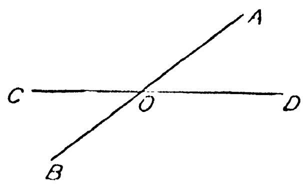
The *magnitude* of an angle may be measured thus. Suppose a straight line rotates, in a plane, about the point O. Let it start from the position OA and rotate into the position OB. Then, the *amount of turning* which the line does in moving from the position OA to the position OB measures the angle. The angle is called the angle AOB, the letter at the vertex being placed between the letters at the other end of the arms. Notice that the *size* of the angle does not depend on the lengths of the arms; the size of the angle AOB remains the same when OA and OB are lengthened.



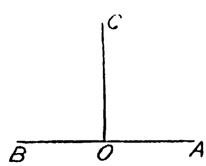


Two angles which lie one on each side of a common arm are called *adjacent* angles. Thus, the angles AOB and BOC, which lie on either side of the arm OB, are adjacent angles.

When two straight lines cross one another, such as AB and CD in the figure, the angles AOD and BOC are called *vertically opposite angles*. So, also, AOC and BOD are vertically opposite angles.



8. If one straight line stands on another straight line and makes the adjacent angles equal, each of the angles is called a *right angle*. Each line is said to be a *perpendicular* to the other. Thus, if OC stands on AB and makes the angle AOC equal to the angle BOC, each of these angles is a right angle.



It is clear that, if a straight line revolves about the point O, starting from the position OA and finishing in the position OB, it must pass through a position in which it is at right angles to AB. Hence, we have the axiom

Through a point in a straight line one, and only one, perpendicular can be drawn to the straight line.

At this stage we do not know how to find the exact position of the perpendicular; we can only estimate it roughly. But in the meantime, if it is required in the course of any other investigation, we are quite justified in saying, "*Let* OC be the straight line which is perpendicular to AB," since we know that there *is* a line which is perpendicular.

Another axiom following from the definition is *All right angles are equal.*

NOTE. A right angle is divided into 90 equal parts called *degrees ;* a degree into 60 equal parts called *minutes ;* a minute into 60 equal parts called *seconds.*

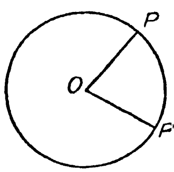
9. An angle less than a right angle is called an *acute* angle.

An angle greater than a right angle but less than two right angles is called an *obtuse* angle.

Two angles whose sum is *one* right angle are called *complementary angles*, and each is the *complement* of the other. Two angles whose sum is *two* right angles are called *supplementary angles*, and each is the *supplement* of the other.

10. A *plane figure* is any portion of a plane surface bounded by one or more lines.

11. A *circle* is a plane figure contained by a line traced out by a point which moves so that its distance from a given fixed point is always the same.



For example, if P moves so that its distance from O is always the same, then the line traced by P encloses a circle.

The line itself is called the *circumference* of the circle.

The fixed point is called the *centre* of the circle.

A straight line drawn from the centre to the circumference is called a *radius.* Hence, all radii of the same circle are equal.

A straight line drawn through the centre and terminated both ways by the circumference is called a *diameter.*

An *arc* of a circle is any portion of the circumference.

A *semicircle* is the figure bounded by a diameter and the portion of the circumference which it cuts off.

12. To *bisect* a thing is to divide it into two equal parts. It is clear that

(i.) Every terminated line has a point of bisection. For, if a point be supposed to move from one end of the line to the other, it must at some instant be exactly half-way.

(ii.) Every angle has a line of bisection. For, in the angle AOB, if a straight line start from the position OA and revolve about O into the position OB, it must pass through a position in which it divides AOB into two equal parts.

The Postulates. It is taken for granted that the three problems stated in the following postulates, or demands, are possible with the help of a straight ruler and a pair of compasses.

1. *A straight line may be drawn from any one point to any other point.*

2. *A terminated straight line may be produced, i.e., made longer.*

3. *A circle may be described with any centre and any radius.* This enables us to transfer distances from one part of a diagram to another; so that, from the greater of two straight lines we can, with the aid of compasses, cut off a part equal to the less.

Problems and Theorems. The propositions discussed in geometry are of two kinds, *Problems* and *Theorems.*

A *problem* requires something to be constructed, such as the drawing of a line which will bisect a given angle.

A *theorem* requires the proof of the truth of some geometrical statement.

The general statement of what the proposition requires us to do is called the *Enunciation.*

The *particular enunciation* is the same statement referred to a diagram.

In the enunciation the *Hypothesis* is that which is assumed to be true; the *Conclusion* is that which has to be proved.

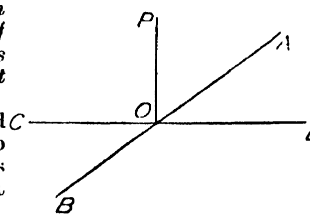
If we have two propositions in which the hypothesis and conclusion of the one form the conclusion and hypothesis respectively of the other, the one proposition is called the *Converse* of the other.

For example. "If two sides of a triangle are equal, the angles opposite to them are equal." The hypothesis here assumes that two sides of a triangle are equal: the conclusion is that the angles opposite to them are equal. Hence, the converse of the proposition is "If two angles of a triangle are equal, the sides opposite to them are equal."

A *Corollary* to a proposition is a statement whose truth follows readily from the result established in the proposition and generally requires no further proof.

Proposition 1. Theorem

If two straight lines cut one another, the sum of the angles on the same side of either line is equal to two right angles.



Let AB and CD be two straight lines which intersect at O.

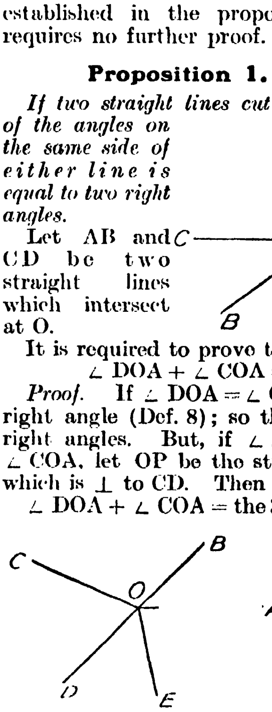
It is required to prove that

$\angle$ DOA + $\angle$ COA = 2 right $\angle$s.

Proof. If $\angle$ DOA = $\angle$ COA then each is a right angle (Def. 8); so that their sum is two right angles. But, if $\angle$ DOA is not equal to $\angle$ COA, let OP be the straight line through O which is $\perp$ to CD. Then

$\angle$ DOA + $\angle$ COA = the 3 $\angle$s DOA, AOP, POC and

$\angle$ DOP + $\angle$ COP = the same 3 $\angle$s.



$\therefore$ $\angle$ DOA + $\angle$ COA = $\angle$ DOP + $\angle$ COP = 2 right $\angle$s.

In the same way it can be shown that any other pair of angles on the same side of either of the lines AB, CD, are equal to two right angles.

Corollary. If any number of straight lines meet at a point, the sum of the consecutive angles is equal to four right angles.

Continued

MILK SELLING & BUTTERMAKING

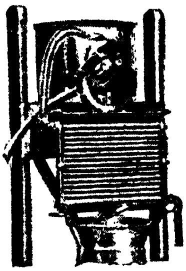
Conveyance of Milk from Farm to Table. Cooling and Aerating Milk. Flavour and Aroma. How to Make Butter. Setting Milk

DAIRY FARMING
continued from page 4038

By Professor JAMES LONG

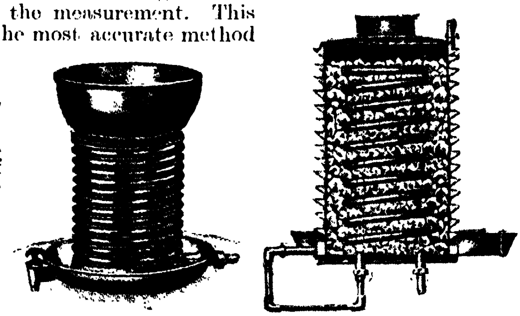
THE SALE OF MILK

From Farmer to Retailer. The bulk of the milk supplied to our large population is produced by farmers who contract to supply wholesale and retail buyers under conditions which are rearranged every half year. There are, however, in or near all towns cowkeepers who retail the milk they produce. The usual prices paid to the farmer are from 13d. to 17d. per barn gallon from March to October, and from 1s. 6d. to 1s. 9d. from October to March; a barn gallon consists of 17 pints, or two imperial gallons and a pint, which, originally thrown in to make up for waste or loss in vending, is now adhered to by the trade, although this particular measure, the "barn," is not a legal one. The farmer is required to deliver his milk twice daily, well cooled, aerated, and sweet, containing at least 3 per cent. of fat—the Government standard—or slightly more in some cases, where firms require high quality. The milk is sent by rail, carriage paid, in metal railway churns, which usually hold 17 gals. imperial. In some parts of England, especially in the North, however, smaller churns or cans are employed for the purpose. The cost of the transit varies with the distance from ½d. to 1½d. per imperial gallon, while the prices realised are higher in the South than in the Midlands. The churns are gauged, and in course of time the constant bruising interferes slightly with the measurement. This principle is wrong, for the most accurate method of buying or selling milk is by weight, although this is difficult in practice.



20. HORIZONTAL COOLER (Showing the new rotary self-cleaning strainer above. Invented by the Dairy Supply Co.)

Keeping Milk Cool. The cooling of milk is imperative, for unless reduced to a temperature of about 50° F. in hot weather it will scarcely keep half a day, or sufficiently long to arrive sweet upon the breakfast or tea table. The system of cooling adopted also provides for the aeration of the milk. There are two forms of cooler—one, which is horizontal [20], consisting of a number of tubes which cold water enters at the bottom and passes out at the top, while the milk runs from a receptacle above over the outside of the tubes, and passes into the churn as it leaves the bottom of the cooler. It will thus be observed that when the milk is coldest it leaves the refrigerator at its coldest point, and thus with sufficiently cold water it may be reduced from a temperature of 90° F. to 50° F. in less than a minute. There is, however, a lenticular cooler [21 & 22], in which the principle adopted is similar, although ice may be packed within the interior in those made for this particular purpose. In both cases the milk passes over the cooler in the form of a thin film, and is therefore well exposed to the air, and its temperature more easily reduced. If cool milk be retailed in vessels which are covered with a white cloth, it should keep sweet during the hottest weather; but on many farms it is impossible to obtain water of sufficiently low temperature, with the result that whole churns of milk occasionally arrive at their destination in an imperfect condition, being for this reason generally returned by the purchaser. Such milk, however, is not valueless; it may still be churned for the production of butter, although the pecuniary result will not be so satisfactory.



21. 22.
LISTER'S LENTICULAR COOLER
In 22 the cooler is packed with ice

Precautions against Contamination. Milk vendors and dealers in general naturally object to the mixing of the milk of two milkings—the morning's with the evening's—which many farmers practise during cold weather in order to avoid two journeys to the railway station; nevertheless, there are many cases in which this practice is permitted. Still stronger objections are made against the milking of cows by persons who are suffering from any disease or who are members of a household in which any infectious or contagious disease exists. For this reason some farmers retain the services both of a veterinary surgeon and medical officer, who from time to time visit the farms, inspect the cattle, and interview the farmer himself. Some of the larger firms of milk vendors refuse to allow members of their staff to enter their premises, or to retail milk under similar conditions, their practice being to pay them their wages until a clean bill of health can be shown. The reader is referred to the article on the Trade of the Dairyman, on page 2215, in which the question

of milk contracts and cognate subjects are more fully treated.

It is obvious that where milk is delivered, as it is by almost every firm in the country, twice daily, the labour involved is considerable, and it is chiefly for this reason that there is so large a difference between the price paid to the farmer and that obtained from the consumer, 4d. a quart being the average figure demanded in this country.

Bad Milk. From the retail dealer's point of view it is important that milk should be produced by cows which are not fed upon improper foods, such as strong-smelling ensilage, half-rotted brewers' grain, turnips, and swedes, which, given in large quantities, convey an ill flavour to the milk, and certain other foods known as distillers' sludge, or even large rations of cabbage. There is, however, a good deal of imperfect, and even impure milk retailed in large cities at 3d. a quart; but whatever may be the desire of the consumer for cheap food this milk should be strictly avoided, for it is impossible, whatever it may have been like as it left the farm, that it could have been handled properly by the retailer.


23. MILK OR CREAM CAN

During very hot and dry weather, milk frequently reaches famine price, and retailers are sometimes compelled to pay as much as 1s. 4d. per imperial gallon in order to satisfy their customers. Milk sold to hospitals and other charitable institutions is naturally sold at lower prices than where it is retailed in large quantities to the public. The wholesale vendor is required to take very little more trouble in the conveyance of 50 or 100 gallons per day than in delivering a few quarts to a number of different houses, but this contract milk is frequently poor in quality, and sometimes impure, although of all places the hospital and the children's home are those where the quality demanded should be of the highest.

Milk Delivery. If milk be *pasteurised*—and the remark equally applies to cream—and suddenly cooled, it will keep longer than when it is simply cooled. In all cases, however, it is the wisest and most business-like plan to deliver milk immediately after it has arrived from the station—servants and customers being advised wherever possible to take care that the vessels in which they receive it are perfectly clean and that it is always kept in the coolest dry apartment in the home. In Paris and many foreign cities milk is delivered daily in bottles which are sealed, and in this way its quality is secured; this plan has been already adopted in this country, and will probably extend far and wide. Similarly, milk which has been sterilised, in hermetically-sealed bottles, is delivered, but only once per week or fortnight, sterilisation ensuring its keeping properties during any reasonable period, and in this way a great deal of labour is saved on the part of the retailer. Milk, however, should never be placed in bottles which have not been cleaned; nothing but actual scalding either with steam or boiling water is efficacious.

In many cases retailing firms send out their milk in locked metal churns, the man in charge drawing it from the tap as his customers require it; but, making every allowance for the shaking which the milk undergoes, the quality at the bottom of the churn is always lower than that at the top, owing to the fact that the cream ascends; the ascent of cream, however, is very slow and slight in milk which is cold. In spite of all precautions, milk carriers occasionally manage to introduce water into the milk they deliver; for this reason inspectors are sometimes employed by large firms to look after them. Such firms take samples of the milk they send out by their servants and are, therefore, able to check them in case a sample was watered before it reaches a customer.

BUTTERMAKING.

Butter made directly from milk, or from cream removed from milk, contains about 86 per cent. of fat, $12\frac{1}{2}$ per cent. of water, and $1\frac{1}{2}$ per cent. of casein, sugar and salt. The more heavily salted the butter, however, the larger the last percentage. The finest butter may contain less than 12 per cent. of water, while in imperfect samples the water present may reach 20 per cent. or even more. In commerce a material is frequently sold which is known as "milk-blended butter;" this sometimes contains as much as 30 per cent. of water which has been worked into it through the medium of milk. Imported butter is usually employed.

The Best Butter. The finest butter is the produce of Channel Islands' cattle—Guernseys and Jerseys—or of herds of which these animals chiefly form part; they add both richness of flavour and colour. Fine butter should be tough, dry, a rich primrose in colour, with a fine, mild, sweet, nutty flavour and a delicate aroma. If a roll be taken in the hands and gently bent it should break gradually and exhibit a grain resembling that of a piece of broken cast steel. If the grain exhibit numbers of drops of water the fact is indicated that it usually contains too much water—although butter may look dry and still contain a high percentage of moisture, for, as shown by Storch, the Danish chemist, a cubic millimetre of butter which has been well worked may contain from 3,000,000 to 4,000,000 globules of water. Heavily-watered butter is soft or brittle, while pickled butter, common to Ireland, perhaps the most inferior product in the British Islands, is not only heavily salted but heavily watered—the result of the process adopted.

Although butter is washed while in grain in the churn, washing should not be overdone, for while it removes the impurities such as curd and sugar, which, if allowed to remain, cause rapid deterioration in quality, flavour and aroma, it is possible to reduce both flavour and colour.

Colour and Flavour. The colour of butter is chiefly due to the breed of cattle employed, but partly to the food supplied, to

sunlight—hence, the paleness of the butter produced in winter—and to excessive washing. The flavour of butter also depends in a large measure upon the breed of cows, upon the food supplied to them, and to the condition of the cream at the time that it is churned. The finest mild butter is the product of sweet cream, and this realises the highest prices in the French market, where we have known it to reach 2s. 8d. a pound. The fullest flavour is obtained when ripened or soured cream is employed, but flavour should not be masked by the employment of too much salt. In the production of a fine mild sample less than a quarter of an ounce to the pound should be used. Storch believes that the flavour of butter is largely derived from the solid materials in the serum of milk and not from the fat; but there is reason to suppose that it is, in part at least, owing to the presence of the volatile fatty acids. Food, however, necessarily affects flavour; hence the change which occurs when turnips, swedes, sour grains and strong smelling herbs are consumed. All difficulties on this score, however, are obviated where cows feed upon fine pastures in summer or are supplied with the best sweet hay, bran, crushed oats, parsnips, and carrots in winter. The fine flavour of butter is not developed until 24 to 48 hours after its manufacture; hence, the mistake often made of judging butter fresh from the churn. At the National Dairy Show, where prizes are sometimes awarded for the best samples on the last day of the Exhibition, while some prize samples are found to have lost both flavour and aroma, others become more perfect.

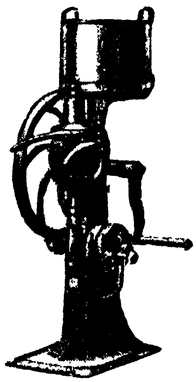
The Aroma. The aroma of butter is due to similar causes to those which affect the flavour. When exposed to air and light the aroma, like the flavour of the outside, changes rapidly, the more so where it is placed in contact with any strong smelling material. The aroma of the interior of a sample is as indicative of quality and even of age as the flavour, but both are affected by heat, which induces decomposition and the development of rancidity. According to Duclaux, than whom no one was more competent to speak, the aroma of butter possibly proceeds from the result of fermentation in the cream; perhaps, indeed, to others, the products of caproic or butyric acid, which are found in all samples of butter in a free state.

Amount of Butter to be Made from Milk. The quantity of butter obtainable from a given quantity of milk may be estimated with much accuracy if the quality of the milk be known. Thus, if we take a sample of milk containing 4 per cent. of fat, which represents milk of high quality, and suppose that a sample of butter contains 14 per cent. of water, we shall find that the milk should produce 4·4 lb., assuming that the separator be employed for the extraction of the cream. The process of skimming would be followed by a loss of ·15 per cent. of fat, and the process of churning by ·05 per cent., or ·20 per cent. in all, leaving 3·8 per cent. of fat with which to deal. If we add to this the water, apart from impurities which ought not to be present—and this we can do by dividing 3·8 by ·86—we get 4·41 lb. of butter to the 100 lb. of milk; that is if the work be performed skilfully throughout.

How Butter is Made. The systems under which butter is now made are as follows:

1. From soured or ripened milk churned at 66° F. This practice, still existing in both Scotland and Ireland, especially where buttermilk is readily saleable, is usually followed by the production of a large yield of butter of fair quality.
2. From cream skimmed from milk set in shallow vessels or pans.
3. From scalded cream. In this case the milk is set in similar but slightly deeper vessels. This practice is common in the three western counties—Somerset, Devon, and Cornwall—the *scalded milk*, as it is termed, being easily saleable.
4. From cream skimmed by the mechanical separator.

In every case in which butter is made from cream it may be the product of sweet cream or matured cream, the latter being sometimes described as ripened or soured, either naturally or artificially. The employment of soured cream necessitates either accurate skill and judgment on the part of the maker, who must determine how far acidity should go by experience and taste, or the aid of a chemical test by which the quantity of acid present is indicated. This quantity may vary in accordance with the character of the butter produced or with the milk employed. Sweet cream produces a smaller quantity of butter than ripened cream, with the result that the buttermilk contains more fat. The butter, however, is milder and sometimes realises a higher price. Most of the butter in the British market is the product of ripened cream, whether it be home produced or imported from foreign countries or our Colonies. The flavour of such butter is fuller, and it is generally believed to keep longer.



24. LAVAL CREAM SEPARATOR

A Model Dairy. In a well-managed dairy, the head of which is highly skilled, the butter produced is practically always the same in character. The dairy and all its utensils and plant should be thoroughly cleansed with boiling water throughout. If the milk, the produce of cows properly fed, be then drawn into clean vessels by clean hands, and the cream removed in perfect condition, the result should be satisfactory; but satisfaction may be practically ensured by the addition to the cream of a small quantity of fresh buttermilk obtained from an adjacent dairy where butter of the finest quality is produced. In this way it is inoculated with friendly bacteria. Thus in most factories and

creameries where milk or cream are obtained from large numbers of farmers, the cream is pasteurised with the object of destroying all bacteria, and subsequently inoculated with what is termed a " pure culture " of bacteria, which are responsible for the production of fine flavour.

Pans versus Separators. In the past, and especially before the introduction of the separator, the system of cold setting of milk was common, especially in the three Scandinavian countries, and in parts of Germany and America. The two systems employed were known as the *Swartz* and the *Cooley* systems. The warm milk was plunged in deep pans in very cold or iced water, with the result that the cream was thin and large in volume, while, being but little in contact with the air, it was not sufficiently oxidised. The system of *shallow* setting in pans already referred to possesses the distinct advantage that the cream is practically all brought into contact with the air, with the result that oxidation is perfect, and the flavour much finer. Cream is also raised in jacketed shallow pans of rectangular form. The jackets are filled as occasion demands with either hot or cold water, and when the cream has risen the skimmed milk is withdrawn from beneath it. All systems of the past are, however, giving way before the separator, and yet no finer butter or cream can be produced than by the simple method of shallow setting.

Points for Buttermakers. There are certain principles involved in butter production which may be formulated as follows:

(1) Cream is extracted from milk by the separator by centrifugal force. The effect of this force is to throw the heavier portions of the milk to the wall or periphery of the cylinder or drum, and thus to keep the lighter fat globules in the centre.

(2) Cream is extracted by shallow setting for the reason that, as already mentioned, being lighter than the serum, it rises to the surface.

(3) Cream rises best in a falling temperature, the larger globules rising first. As the temperature falls, the fat, being a non-conductor, does not feel the change to the same extent as the serum, with the result that the difference in the density of the two materials is widened, and it rises all the quicker in consequence.

(4) If milk be cooled before setting, the cream rises imperfectly.

(5) Cream should be aerated that it may part with any objectionable odour or flavour, and be the better oxidised. The higher the temperature at which milk is set after coming from the cow at, say, 95° F., and the lower the temperature of the apartment in which it stands for the cream to rise, placing 40° F. as a minimum, the better the cream rises.

(6) If milk be re-heated before setting for cream there is a loss involved.

For the purposes of raising cream on the shallow system, the vessels employed are usually of metal, glass, porcelain, or earthenware. They are round, and vary from 18 in. to 24 in. in diameter. Where the cream is scalded, however, they are slightly deeper than under other conditions, and furnished with handles on either side to facilitate manipulation to and from the stove. In no case should the dairy in which cream is set in these vessels be higher than 60° F., or the cream rises less perfectly, while acidity is induced by the heat before the fat globules have had time to reach the surface. Where the system of scalding is practised, a pan of milk having been set in the dairy for twelve hours, or longer, if in the judgment of the dairymaid, the cream has not all risen, it is placed upon the stove—preferably into a vessel of water that it may not burn—until the cream be covered with a film, and has reached a temperature of 175° F. If by accident the milk be allowed to boil, a small quantity of cold water should be immediately added, but this will not altogether remedy the mistake. This heating process is practically pasteurisation, with the result that bacteria are killed, and both cream and butter keep sweet longer.

The Separator. The important modern machine known as the *cream separator* is now made in many forms [**24**], but in all cases the same principle is adopted. The milk passes into a receptacle, usually a bowl or cylinder, the heavier solids it contains being repelled from the centre, around which the lighter portions—the fat globules which form the chief portion of the cream—gather. As the inflow continues, the pressure it exerts is followed by a corresponding outflow, the cream finding its way through one orifice and the separated milk through another, both being conveniently placed for the purpose. All the best machines are now provided with discs of different forms, which divide the milk into layers, and thus facilitate its separation, with the result that much larger quantities are handled than was possible formerly. The thickness of the cream is regulated not only by the size of the orifice, but by heat, the temperature of the milk being now controlled to a great nicety in all large butter-making establishments, with the result that much better work is performed; but the separation of the cream from the milk is only perfect—which means that not more than ·15 per cent. of the fat is left behind—when the conditions are perfect. The speed—that is, the number of revolutions—must be correct, while the temperature of the milk and its inflow must be carefully regulated. Whatever instructions may be provided by the makers of a separator, the skilful operator will ascertain for himself how many revolutions per minute, what temperature, and what inflow will enable him to obtain the best results. The separated milk, as it leaves the machine, is sometimes cooled rapidly that it may be kept for sale or for return to the farms; or, if not heated to a high temperature before separation, it may be first pasteurised and subsequently cooled, plant being now obtainable for that purpose. Sour or imperfect milk cannot be separated with good results. The scum adhering to the sides of the separator should be removed by thorough cleansing after each day's operation. Since the first public trials in Denmark and Hamburg, in 1883, and subsequently in Paris, separation by centrifugal machines has been improving until the

work of to-day is as nearly perfect as possible; yet we look forward with confidence to something still greater—the production of the butter direct from the cow. This will involve the invention of a more perfect milking machine from which the uncontaminated milk will pass into the separator, and from the separator into an instantaneous buttermaker—a machine which, if still imperfect, has already been invented.

Strainers. All cream should be strained before churning. Many forms of strainer have been invented, but none are really perfect, with the result that cloths are still employed. A hair strainer, however, may be used for straining the butter, the buttermilk, and the water or brine as each leaves the churn. For butter production in a private dairy, the cream, as it is skimmed, should be mixed and stirred after each skimming, a glazed earthenware vessel being kept for the purpose; but churning should never begin until twelve hours have elapsed since the last cream was added; nor, if the best product is to be obtained, should any cream be more than twenty-four hours old if it has been kept, as it should be, in a dry apartment at 60° F. At this temperature, cream skimmed from a shallow vessel while perfectly sweet should be quite mature or ripe in 24 hours. Where cream is churned under these conditions it produces butter of finer flavour, chiefly owing to its more perfect oxidation, than anything which is produced in the creamery or factory—or, indeed, wherever the practice of inoculation be carried out. If cream, when ready for churning, be too small in volume for the churn employed, that volume may be increased by the addition of a portion of the skimmed milk from which subsequent cream has been removed, conditionally upon its being clean and pure; but this method is not applicable to the factory. Ripe or mature cream is thick, owing to the production of lactic acid, and the resulting coagulation of the casein. Such cream produces from 15 per cent. to 25 per cent. more butter than perfectly sweet cream which has been raised, for example, in twelve hours at a temperature of 60° F. If sweet cream be mixed with ripe cream, there is a corresponding loss; in other words, the loss will be in proportion to the quantity of sweet cream employed. In no case should cream—or, indeed, milk—be set in a badly-ventilated, dark, or damp apartment; it is practically certain to be spoiled in flavour and to produce ill-flavoured butter, owing to the fact that it is attacked by organisms which are peculiar to such apartments, but which are seldom if ever found in sunlight.

Regulating the Temperature. When cream is ready for churning it should be brought to the required temperature, otherwise there may be loss both of quantity and quality; in summer, 55° F. to 56° F. will be found the most convenient, while in winter the temperature may be raised to 64° F. It depends, however, upon the temperature of the apartment in which the work takes place. In winter the churn should be scalded, and thus prepared, so that after the cream has been placed within it its temperature may not fall. Similarly, in summer, the churn may be cooled after scalding, to prevent a rise in the temperature of the cream. The object should be to obtain small, well-formed, crisp granules of butter which are easily washed and brined. If the granules be too large or too soft, washing is necessarily imperfect—the large granules enclosing buttermilk, which cannot be removed, while those which are soft resist the action of water. In a private dairy, where churning is not practised at least every other day, it is difficult to obtain butter of the finest quality; therefore, whatever care be exercised in feeding the cattle, in milking cows, in setting and skimming the cream, we must look for imperfect results if that cream be kept too long. It is indispensable that a tested thermometer should be used in every operation; it will indicate the suitability or not of the temperature of the dairy, of the cream, and of the water employed in washing the butter. It is still more necessary where milk or cream is pasteurised.

Avoidance of Sudden Changes. In order to obtain the required temperature of the cream before churning, usually it is necessary to heat it in winter or to cool it in summer; either process must be gradual, sudden heating or cooling, or heating or cooling too many degrees at one time, being fatal to success, and here the ingenuity of the maker will be tested. Neither hot nor very cold water, nor ice, should be added to cream on any consideration; nor should it be heated or cooled more than three or four degrees at one time, and this only by the addition of pure water, or by standing the cream vessel in hot or cold water, and keeping it gently stirred. In factory and creamery work the temperature is regulated by heating the apartment in which the cream is placed, and by arrangements so carefully made that it is churned immediately it is fit for the purpose. In buttermaking the operator should on all occasions note the aroma and flavour of cream before churning, and compare the subsequent aroma and flavour of the butter produced from it. In this way he will be able to indicate with great accuracy precisely when cream is ready to churn. If cream has been pasteurised on milk in an open vessel, or clotted, as in the Western Counties, it may be churned at a temperature of 58° F., although it is quite a common practice among many makers to stir clotted cream into butter, and subsequently to work the butter with the naked hand—both of which methods are carefully to be avoided.

Continued

ITALIAN—FRENCH—GERMAN—SPANISH

Italian by F. de Feo; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten; Spanish by Amalia de Alberti and H. S. Duncan

ITALIAN

Continued from page 4072

By Francesco de Feo

IRREGULAR VERBS

Second Conjugation

VERBS IN **ere** (long)

Sapére, to know (I know *something*)

Ind. Pres.—So, sai, sa, sappiamo, sapete, sanno.

Imperf.—Sapevo, sapevi, etc.

Past Defin.—Seppi, sapesti, seppe, sapemmo, sapeste, seppero.

Future—Saprò, saprai, saprà, sapremo, saprete, sapranno.

Imperat.—Sappi, sàppia, etc.

Pres. Subj.—Sàppia, sappia, sappia, sappiamo, sappiate, sàppiano.

Imp. Subj.—Sapessi, sapessi, etc.

Conditional—Saprei, sapresti, saprebbe, etc.

Past Part.—Saputo.

Dovère, to owe, to be obliged

Pres. Ind.—Devo (debbo), devi, deve, dobbiamo, dovete, dèvono ((dèbbono), I must, etc.

Imperf.—Dovevo, dovevi, etc.

Past Def.—Dovei and *dovetti, dovesti, dovette (dovè), dovemmo, doveste, dovèttero (dovèrono).*

Future—Dovrò, dovrai, dovrà, etc.

Pres. Subj.—Debba, debba, debba, dobbiamo, dobbiate, dèbbano.

Imp. Subj.—Dovessi, dovessi, etc.

Conditional—Dovrei, dovresti, etc.

Past Part.—Dovuto.

Volére, to be willing

Ind. Pres.—Voglio (vo'), vuoi, vuol(e), vogliamo, volete, vògliono.

Imperf.—Volevo, volevi, voleva, etc.

Past Def.—Volli, volesti, volle, volemmo, voleste, vòllero.

Future—Vorrò, vorrai, vorrà, vorremo, etc.

Pres. Subj.—Vòglia, vòglia, voglia, vogliamo, vogliate, vògliano.

Imp. Subj.—Volessi, volessi, etc.

Conditional—Vorrei, vorresti, vorrebbe, etc.

Past Part.—Voluto.

Vedére, to see

Pres. Ind.—Vedo (lit. veggo), vedi, vede, vediamo, vedete, vèdono.

Imp.—Vedevo, vedevi, etc.

Past Def.—Vidi, vedesti, vide, vedemmo, vedeste, videro.

Future—Vedrò, vedrai, vedrà, etc.

Imperat.—Vedi (ve'), veda, etc.

Pres. Subj.—Veda (vegga), etc., *vediamo, vediate, vèdano.*

Imp. Subj.—Vedessi, vedessi, etc.

Conditional—Vedrei, vedresti, vedrebbe, etc.

Past Part.—Veduto and *visto.*

The compound *prevedére* (to foresee), *provvedére* (to provide), and *travedére* (to see indistinctly), in the future and conditional are regular: *prevederò, prevederei, provvederò*, etc.

Potére, to be able

Pres. Ind.—Posso, puoi, può, possiamo, potete, pòssono (I can).

Imperf.—Potevo, potevi, etc.

Past Def.—Potei, potesti, etc.

Future—Potrò, potrai, potrà, etc.

Pres. Subj.—Possa, etc.; *possiamo, possiate, pòssano.*

Imp. Subj.—Potessi, potessi, etc.

Conditional—Potrei, potresti, etc.

Past Part.—Potuto.

Tenére, to hold, to keep

Pres. Ind.—Tengo, tieni, tiene, teniamo, tenete, tèngono.

Imperf.—Tenevo, tenevi, etc.

Past Def.—Tenni, tenesti, tenne, tenemmo, etc.

Future—Terrò, terrai, terrà, etc.

Imperat.—Tieni, tenga, teniamo, tenete, tèngano.

Pres. Subj.—Tenga, etc.; *teniamo, teniate, tèngano.*

Imp. Subj.—Tenessi, etc.

Conditional—Terrei, terresti, etc.

Past Part.—Tenuto.

Conjugate like *tenere*: *appartenére*, to belong, *contenére*, to contain, *ritenére*, to retain, *sostenére*, to sustain, etc.

ESERCIZIO DI LETTURA

. . . Dovete dunque sapère che, in quel convento, c'era un nostro padre, il quale era un santo, e si chiamava il padre Macàrio. Un giorno d'inverno, passando per una viòttola, in un campo d'un nostro benefattore, uomo dabbene anche lui, il padre Macàrio vide questo benefattore vicino a un suo gran noce; e quattro contadini, con le zappe[1] in aria, che principiàvano a scalzàr[2] la pianta, per mètterle le radici[3] al sole. Che fate voi a quella pòvera pianta? domandò il padre Macàrio. Eh! padre, son anni e anni che la[4] non mi vuol far noci; e io ne fàccio legna. Lasciàtela stare, disse il padre: sappiate che, quest'anno, la[4] farà più noci che fòglie. Il benefattore, che sapeva chi era colui che aveva detta quella parola, ordinò sùbito ai lavoratori, che gettasser di nuovo la terra sulle radici; e, chiamato il padre, che continuava la sua strada, padre Macàrio, gli disse, la metà della raccolta sarà per il convento. Si sparse la voce della predizione; e tutti corrèvano a guardare il noce.

Infatti, a primavera, fiori a bizzeffe,[5] e, a suo tempo, noci a bizzeffe. Il buon benefattore non ebbe la consolazione di bacchiarle;[6] perchè andò, prima della raccolta, a ricèvere il prèmio della sua carità. Ma il miràcolo fu tanto più grande, come sentirete.

1, pick-axe; 2, to bare; 3, root; 4, it; 5, in abundance, plenty; 6, to shake.

PERSONAL PRONOUNS—continued

Tu, Voi, Lei. In addressing a person we may use the pronoun of the second person singular, *tu* (*dare del tu*); or the pronoun of the second person plural, *voi* (*dare del voi*); or the feminine pronoun of the third person singular, *lei* (*dar del lei*).

1. *Tu* is used in addressing children, relatives, very intimate friends. Examples: Where are you going, Peter? *Dove vai, Pietro?* Speak, my child, *Parla, bambino mio.*

2. *Voi* is used in addressing a person to whom we desire to show a *certain* deference, or with whom we do not wish to be too familiar.

Examples: You have not studied enough to-day, *Voi non avete studiato abbastanza oggi*; You are a good man, *Voi siete un buon uomo.* The adjective referring to *voi* (sing.) is in the singular. You are very kind, *Voi siete molto gentile.*

3. *Lei* is the usual form of address (except in the cases mentioned above): for the plural, *loro* is used. Example: You must excuse me, *Lei mi deve scusare*; You (plural) are right, *Loro hanno ragione.*

4. The verb must, of course, agree in person and number with the personal pronoun used in addressing a person. The pronouns also in this case are generally omitted: *entra, entrate, entri, èntrino.*

5. In addressing a man in the third person the adjective referring to the pronoun *may* be in the feminine, as *lei* stands for the feminine *Vossignoria* (your lordship); *Lei sarà contento* (or *contenta*) *di sapere*, You will be pleased to know.

6. *Your, yours* when speaking in the third person must be translated by *suo, sua, suoi, sue, loro*; *suo padre*, your father; *le sue sorelle*, your sisters; *i loro amici*, your friends. In writing, *Ella* may be used instead of *lei*, as, *Scrivo sùbito perchè Ella ne sia informata*, I am writing at once in order that you should be informed of it.

7. For you (*obj.*) the conjunctive forms *la, le* must be used. If a conjunctive pronoun is used the adjective must be feminine. Example: *La prego di scusarmi*, I beg you to excuse me. So the forms to be used when speaking or writing in the third person, whether the person addressed be a man or a woman, are as follow:

you (*subj.*)—*lei*, or *Ella* (sing.), *loro* (plural)
you (*obj.*)—*la* (sing.), *le* plural)
to you—*le* (sing.), *loro* (plural)
it, him, them, etc. to you—*glielo,-a,-i,-e*
of it, of him, of them, etc. to you—*gliene*

Exercise XXXII.

1. Noi si parlava di lei. 2. Lei è gentilissima. 3. Mi fàccia il piacere di darmi quello spillo. 4. Mi scusi se non glieli ho mandati più presto. 5. Le prometto che fo uno spropòsito se lei non mi dice sùbito sùbito il nome di colui. 6. Amico mio, tu hai torto: domanda un po' a tua sorella; non è vero, signorina, che lei è informata di tutto? 7. Siete ben pronta a parlare senz' èssere interrogata. 8. Lei è la più cara persona che io àbbia mai conosciuta; come fa a èssere sempre così allegra? 9. Suo fratello mi disse che lei era ritornata in città, e mi sono affrettato a venire a strìngerle la mano. 10. Si è divertita questi lunghi mesi d'inverno? 11. Perchè stanno sulla porta al freddo? èntrino. 12. Lei non sa, non saprà mai quanto sincera fosse la mia amicìzia per suo figlio. 13. Àbbia la gentilezza di mèttere questa lèttera alla posta quando va fuori. 14. La ringràzio tanto tanto dei bei fiori che mi ha mandati. 15. Loro crèdono che tutto si possa fare a tambùr battente; ci vuol tempo per tutte le cose. 16. Le sue amiche la prègano di volère andàr giù in giardino, se non le dispiace. 17. Glieli mostrerò.

Conversazione

Chi le ha detto che l'affare non si farà?

Lo so; e vedrà che ho ragione.

La ringrazio della sua gentilezza e la prego di comandarmi in tutto ciò che posso.

Non si dia pensiero di me; saprò come regolarmi.

Ho saputo che i suoi lavori sono stati accettati; gliene faccio i miei complimenti.

Grazie, ma non dica niente a mio padre, perchè voglio fargli uno sorpresa.

E loro stanno sempre in campagna?

Sì, e forse ci resteremo per due o tre mesi ancòra. Speriamo che ci farà l'onore di una sua visita un giorno o l'altro.

Da quanto tempo non vede il signor N?

Lo vidi in casa Sarti due mesi fa (*ago*).

Dov'è il mio giornale?

Scusi tanto, signorina, non ci ho pensato; ma le prometto che stasera al più tardi glielo farò avere.

Se non vuol farlo, ce lo dica.

Non è che non voglio, non posso. Loro non sanno quanto sia difficile di ottenere qualche cosa da quella gente. A ogni modo proverò, e gliene farò sapere qualche cosa.

Key to Exercise XXIX.

1. We had thought to sell him some tickets, but he has not wished to buy any. 2. They have shown me some of different qualities. 3. If I had some more, I would give some to you. 4. Where is your aunt? 5. There she is; speak of it to her. 6. These little pictures are very beautiful; if you go to Italy do not forget to buy some for me. 7. I have bought some beautiful toys for this little boy, but I have forgotten to bring them to him. 8. Do not bring them to him, because he has been naughty all day. 9. If the dressmaker has

finished my dress, tell her to send it to me directly. 10. I shall not fail to tell her of it.

KEY TO EXERCISE XXX.

1. Non vedete che la fàccia di questa bambina è tutta sporca di fumo? lavàtegliela. 2. Se avete delle rose e dei garòfani freschi, fàtene un bel mazzolino e mandàtelo a questo indirizzo. 3. Vi avevo pregato di non dirle niente, e voi le avete raccontato tutto. 4. Ecco la lèttera che abbiamo ricevuta, leggètegliela e vedete che impressione le fa. 5. Se avesse detto a noi tali parole, avremmo saputo come rispònderle per le rime. 6. Questo telegramma vi è stato rimesso alle sette e venti, come va che me lo date dopo più di due ore? 7. Se volete andare a teatro, andàteci; io preferisco di non uscire. 8. Lo tratterò come un mio fratello, ve lo prometto. 9. Ecco il telegramma che abbiamo ricevuto: "Ricevuto biciclette: spedirèmovele." 10. È in Italiano, non lo capisco; traducètemelo, per piacere.

KEY TO EXERCISE XXXI.

1. That boy was saved by a miracle. 2. To-day the new railway time-table has been published. 3. The workmen are paid every five days. 4. We were invited, but we did not go (there). 5. He is loved and esteemed by all who know him. 6. I am sorry I cannot accept your invitation, because I must soon start for Rome, where I have been summoned by telegram. 7. Stick no bills. 8. It is said that war between the two countries is now inevitable. 9. They say that General N. has been wounded in the last battle. 10. Don't be tiresome, otherwise thou wilt be avoided by everybody. 11. This little story has been related to us by a friend of ours. 12. The miser is attracted by gold, as iron by the magnet. 13. The fire has been finally isolated; but twenty houses and two coal-stores have been entirely destroyed. 14. The thief has been arrested.

Continued

FRENCH

By Louis A. Barbé, B.A.

VERBS—continued

Pronominal Verbs Conjugated Interrogatively

Pronominal verbs are conjugated interrogatively:

1. In simple tenses, by putting the pronoun subject after the verb.
2. In compound tenses, by putting the pronoun subject after the auxiliary verb.

These verbs may, like all other verbs, be conjugated interrogatively by prefixing *est-ce que* without inversion. This form is most commonly used in the case of the first person singular of the simple tenses, and is the only one that will be given here:

Se flatter, conjugated interrogatively

INDICATIVE

Present

Do I flatter myself?
est-ce que je me flatte?
nous flattons-nous?

Imperfect

Did I flatter myself?
est-ce que je me flattais?
nous flattions-nous?

Past Definite

Did I flatter myself?
est-ce que je me flattai?
nous flattâmes-nous

Future

Shall I flatter myself?
est-ce que je me flatterai?
nous flatterons-nous?

COMPOUND TENSES

Past Indefinite

Have I flattered myself?
me suis-je flatté, or *flattée?*
nous sommes-nous flattés, or *flattees?*

Pluperfect

Had I flattered myself?
m'étais-je flatté, or *flattée?*
nous étions-nous flattés, or *flattées?*

Past Anterior

Had I flattered myself?
me fus-je flatté, or *flattée?*
nous fûmes-nous flattés, or *flattées?*

Future Anterior

Shall I have flattered myself?
me serai-je flatté, or *flattée?*
nous serons-nous flattés, or *flattées?*

CONDITIONAL

Present

Should I flatter myself?
est-ce que je me flatterais?
nous flatterions-nous?

Past

Should I have flattered myself?
me serais-je flatté, or *flattée?*
nous serions-nous flattés, or *flattées?*

Pronominal Verb Conjugated Interrogatively and Negatively

INDICATIVE

Present

Do I not perceive?
est-ce que je ne m'aperçois pas?
ne nous apercevons-nous pas?

Imperfect

Did I not perceive?
est-ce que je ne m'apercevais pas?
ne nous apercevions-nous pas?

Past Definite

Did I not perceive?
est-ce que je ne m'aperçus pas?
ne nous aperçûmes-nous pas?

Future

Shall I not perceive ?
est-ce que je ne m'apercevrai pas ?
ne nous apercevrons-nous pas ?

COMPOUND TENSES

Past Indefinite

Have I not perceived ?
ne me suis-je pas aperçu, or *aperçue ?*
ne nous sommes-nous pas aperçus, or *aperçues ?*

Pluperfect

Had I not perceived.
ne m'étais-je pas aperçu, or *aperçue ?*
ne nous étions-nous pas aperçus, or *aperçues ?*

Past Anterior

Had I not perceived ?
ne me fus-je pas aperçu, or *aperçue ?*
ne nous fûmes-nous pas aperçus, or *aperçues ?*

Future Anterior

Shall I not have perceived ?
ne me serai-je pas aperçu, or *aperçue ?*
ne nous serons-nous pas aperçus, or *aperçues ?*

CONDITIONAL

Present

Should I not perceive ?
est-ce que je ne m'apercevrais pas ?
ne nous apercevrions-nous pas ?

Past

Should I not have perceived ?
ne me serais-je pas aperçu, or *aperçue ?*
ne nous serions-nous pas aperçus, or *aperçues ?*

EXERCISE XXIX.

Of the pronominal verbs that have the second pronoun for their direct object, some take the preposition *à*, others the preposition *de*, before their indirect object. These prepositions are indicated in the following list of verbs that occur in the exercise :

s'aider, to help oneself
s'apercevoir de, to perceive
s'appeler, to be called
s'arrêter, to stop
se battre, to fight
se défendre, to defend oneself
se défier de, to distrust
se déguiser, to disguise oneself
se dévouer, to devote oneself
s'emparer de, to take possession of, to seize
s'ennuyer de, to weary of
se glorifier de, to be proud of
se méfier de, to mistrust
se mettre à, to set about, to begin
se plaire à, to take pleasure in
se ralentir, to slacken
se trouver, to find oneself, to happen to be
se vanter de, to boast of

1. It seems to me that I have already seen that lady. What is her name ? (How does she call herself ?)

2. The vanquished (*vaincu*) have not fought less well than the victors (*vainqueur*).

3. The enemy (singular) have taken possession of the town, after a long siege, during which the inhabitants defended themselves as courageously (*courageusement*) as the soldiers.

4. We distrust others too much, and we do not mistrust ourselves sufficiently.

5. There are men who are prouder (glorify themselves more) of their defects (*le défaut*) than of their good qualities.

6. "Help thyself, heaven will help thee," says the proverb.

7. They (f.) perceived their error, but it was too late.

8. A writer (*écrivain*) has said that if we often boast of not wearying, it is because we are so conceited (*glorieux*) that we do not wish (*voulons*) to consider (find) ourselves (*de*) bad company (*la compagnie*).

9. At what time do you usually (*ordinairement*) get up ? We usually get up at half-past seven, and we rarely go to bed before half past eleven.

10. Great motives may (*peuvent*) induce (*engager*) us to humble (*humilier*) ourselves, none to demean (*avilir*) ourselves.

11. The Romans, after having taken possession of Gaul (*la Gaule*), gave it in a short time their civilisation.

12. It is (*vaut*) better to expose oneself to ingratitude than to leave a wretched (man) (*malheureux*) without help (*secours*).

13. History tells us that there have been kings who devoted (*dévouer*) themselves to death for the safety (*le salut*) of their people.

14. There is a great deal of difference between (*entre*) taking pleasure (*se plaire*) in a (*à*) work and being suited (*propre*) for (to) it.

15. We are so accustomed (*accoutumés*) to disguise ourselves to others, that in the end (*enfin*) we disguise ourselves to ourselves.

16. It is as easy to deceive (*tromper*) oneself without perceiving it, as it is difficult to deceive others without their (that they) perceiving it.

Passive Verbs

1. Verbs in the passive voice, or passive verbs, as they are commonly called (*verbes passifs*), consist of the past participle of an active verb added to the verb *être*, to be. Thus, *aimer*, to love ; *être aimé*, to be loved ; *j'aime*, I love ; *je suis aimé*, I am loved ; *La mère a grondé l'enfant*, The mother has scolded the child ; *L'enfant a été grondé par sa mère*, The child has been scolded by his mother.

2. In passive verbs, the past participle always agrees with the subject : *Jeanne d'Arc fut brûlée sur la place publique de Rouen*, Joan of Arc was burnt in the public square at Rouen.

3. In conjugating a passive verb, it must be remembered that *je, tu, nous, vous* may stand for feminine subjects, and that in such a case the past participles must be feminine also.

4. As the conjugation of the passive voice presents no difficulty, it will suffice to give one simple tense and one compound tense as models :

Present Indicative

I am loved, etc.
je suis aimé, or *aimée*
tu es aimé, or *aimée*
il est aimé, elle est aimée
nous sommes aimés, or *aimées*
vous êtes aimés, or *aimées*
ils sont aimés, elles sont aimées

Past Indefinite

I have been loved, etc.

j'ai été aimé, or *aimée*
tu as été aimé, or *aimée*
il a été aimé, elle a été aimée
nous avons été aimés, or *aimées*
vous avez été aimés, or *aimées*
ils ont été aimés, elles ont été aimées

5. The subject of a verb in the passive voice can only be that which would be the direct object or accusative of the same verb in the active voice. The indirect object or dative of the active may never be the subject of the passive voice. Thus, the verb *dire*, to tell, requires the indirect object: *je lui dis*, I tell (to) him. Consequently, such a construction as "I have been told" is impossible in French. We must say, *on m'a dit*, one has told me, or *il m'a été dit*, it has been told me.

6. The passive construction is used far less frequently in French than it is in English. In the former language it is very commonly rendered by an active construction with *on* as subject, or by means of a reflexive verb: It is said that the enemy have taken possession of the town, *On dit que l'ennemi s'est emparé de la ville*; That word is not found in the dictionary, *Ce mot ne se trouve pas dans le dictionnaire*

Neuter Verbs

1. The neuter, or intransitive, verb (*verbe neutre ou intransitif*) is that which can never have a direct object or accusative, and which, consequently, has no passive voice.

2. Some neuter verbs are conjugated with *être* as their auxiliary, in the compound tenses. The more common of these are:

aller, to go	*partir*, to go away
arriver, to arrive	*rester*, to remain
entrer, to enter	*sortir*, to go out
mourir, to die	*tomber*, to fall
naître, to be born	*venir*, to come, and some of its derivatives.

Continued

GERMAN

Continued from page 4077

By P. G. Konody and Dr. Osten

XCII. Attributive Clauses. The attributive clause represents the attribute to the subject in the principal sentence, and is generally joined to the other parts of the sentence by the conjunction daß, or by interrogative or relative pronouns. As a substitute for an attribute, the attributive clause, like the attribute, answers to the question was für ein? what sort of? In the sentence: Er gab mir den Beweis der Wahrheit seiner Dar'stellung, He gave me the proof of the truth of his version, the substantive attribute answering the question Was für einen Beweis? is: Den Beweis der Wahrheit, etc. The attributive clause, by which it may be replaced, would be: Er gab mir den Beweis, d a ß seine Darstellung wahr sei, He gave me the proof that his version is true.

XCIII. Relative Clauses. Attributive adjectives can be replaced by attributive clauses connected with the principal sentence by the relative pronouns der, die, das, welcher, was, or by the conjunctions [see XLV., 2] wo, da, wie, wann, etc. The relative pronouns agree in gender and number with the corresponding noun in the principal sentence, but the case is determined by the predicate of the subordinate clause. In the sentence: Ein kahler Baum erquickt das Auge nicht, A barren tree does not please (refresh) the eye, the adjective-attribute kahl can be replaced by an attributive (relative) clause: Ein Baum, der kahl ist, erquickt das Auge nicht, A tree that is barren, etc. Ich liebe nicht fehlerlose Kinder, I do not like faultless children, and: Ich liebe nicht Kinder, die fehlerlos sind. Dies ist ein Mann, d e s s e n Hilfe ich bedarf, This is a man whose help I need. Dies ist ein Mann, d e m (3) nicht geholfen werden kann, This is a man to whom help cannot be given. Dies ist ein Mann, d e n ich brauche, This is a man whom I want. Dies sind Leute, d i e wir kennen, These are people whom we know. Dies ist eine Frau, d e r e n Hilfe ich bedarf, This is a woman whose help I want. In these examples it will be seen that gender and number of the relative pronouns are determined by the nouns to which they refer, whilst the case is influenced by the predicate of the relative clause. Sometimes the relative pronoun is dependent on the adjunct substantive, in which case it must be in the genitive (dessen, deren): Dies ist ein Mann, an d e s s e n Beifall mir liegt, This is a man whose approval I care for.

1. If the attributive clause refers to a substantive, the relative pronouns der, die, das, and welcher, welche, welches, are employed. The choice between the two groups is generally decided by euphony: Er brachte den Tisch, welchen (or den) ich gestern gekauft hatte, He brought the table which I [had] bought yesterday. But if the relative clause refers to a personal pronoun, only the relative pronouns der, die, das, are admissible: Wir sahen ihn, der (not welcher) uns früher Auskunft gegeben hatte, We saw him who had previously given us information. Er beleidigte mich, den (not welchen) er zum ersten Male sah, He insulted me whom he saw for the first time.

2. If the relative clause refers to the *neuter* of a demonstrative pronoun, or of a substantive, or of an indefinite numeral, it has to be introduced by the relative pronoun was, or its contraction with prepositions, like womit, wodurch, wozu, woraus, etc. Examples: Er sagte mir A l l e s w a s er wußte, He told me all he knew. If the relative clause refers to a substantive, was and its contractions are usually not employed: Das Bett, das (not was) ich kaufte, The bed which I bought. The relative pronoun was is, of course, subject to declension.

3. Relative Adverbs are: wo (wohin), da (als, wenn)—wo referring to place, and da to time. Wo (wohin) is used instead of an dem Orte, an welchem . . . . (an den Ort, an welchen . . . .), in the place where . . . . ; and da (als, wenn) instead of

zu der Zeit, in welcher ..., at the time when ... etc. Examples: Kennst du das Land, wo die Citronen blühn? (Goethe), Knowest thou the land where the lemons blossom? Am Tage, da wir uns zum ersten Male sahen, On the day when we saw each other for the first time.

4. The contraction of relative clauses lends more vigour and terseness to the sentence. The relative clause in the sentence Der Graf, der ein vorzüglicher Reiter war, stieg in den Sattel, The count, who was an excellent horseman, mounted into the saddle, can be contracted by the omission of the relative pronoun „der" and the finite auxiliary (copulative) verb „war": Der Graf, ein vorzüglicher Reiter, stieg in den Sattel. The contracted part of the relative clause takes the case of the noun to which it refers: Der Rat des Arztes, der ein Freund unserer Familie war, schien gut, The advice of the doctor, who was a friend of our family, seemed good; but Der Rat des Arztes, eines Freundes unserer Familie, schien gut.

If the predicate of the relative clause is a verb in the passive voice, the relative pronoun is dropped and the verb takes the past participle: Er lebt in einem Dorfe, (welches) Gernhausen genannt (wird), He lives in a village (which is) called Gernhausen.

XCIV. Adverbial Clauses. According to the different groups of adverbs there are adverbial clauses of place, time, manner, cause, etc., which can be placed at the beginning, at the end, or in the middle of the sentence. The adverbial clause must not be confounded with the ordinary adverbial phrase of place, time, etc. The former is a *complete* clause with subject and predicate. Thus, wo immer, an allen Orten, wherever, in all places, are merely adverbial phrases of place; whilst Wo immer ich auch bin, Wherever I may be, is an adverbial clause of place, with subject and predicate.

1. The adverbial clause of place answers to the questions Wo? Where? Wohin? Whither? Woher? Whence? by which conjunctions it is generally introduced; whilst the correlatives, da, dort, etc. frequently occur in the principal sentence: Wo Licht ist, da ist auch Schatten, Where there is light, there is also shadow. To distinguish between adverbial clauses and attributive clauses of place, which are introduced by the same conjunctions, it should be remembered that the former answers to the question Wo? etc., and the latter to Was für ein? Wo ich geboren bin, ist meine Heimat, Where I was born is my home, is an adverbial clause of place. (Question: Wo ist meine Heimat?) But in Der Ort, wo ich geboren bin, ist meine Heimat, The place where I was born is my home, the relative clause is attributive. (Question: Was für ein Ort?)

2. The adverbial clause of time answers to the questions Wann? When? Wie lang? How long? Seit wann? Since when? Bis wann? Till when?

(*a*) If the actions in the principal sentence and in the dependent clause coincide, these clauses are introduced by the conjunctions als, wie, wenn, wann, sobald, sowie, während: Als er kam, ging ich fort, As he came, I went away. Er wollte einsteigen, während der Zug abging, He wanted to get in whilst the train was starting, etc. The predicates of both parts of the sentence take, of course, the same tense. If the conjunctions wenn and wann are omitted the sequence of words is the same as in an interrogative sentence: Wenn ich wiederkomme, wollen wir fröhlich sein, When I return we will be merry; but: Komme ich wieder, wollen wir fröhlich sein.

(*b*) If the action of the dependent clause precedes that of the principal sentence, the former is introduced by nachdem, after: Nachdem ich ihm meine Meinung gesagt hatte, beruhigte er sich, After I had told him my opinion, he calmed down. Here the imperfect in the principal sentence corresponds with the pluperfect in the dependent clause.

(*c*) If the action of the principal sentence precedes that of the dependent clause, the latter is introduced by ehe, bevor, before: Tue es, ehe es zu spät ist, Do it, before it is too late.

(*d*) The adverbial clauses answering to Wie lange? How long? Seit wann? Since when? Bis wann? Till when? are introduced by the conjunctions seit, since; bis, till; indem, während, whilst; indes, meanwhile; solange, as long as; and nun, now: Seit du da bist, fühle ich mich wieder wohl, Since you have been (are) here, I feel well again. Bleiben Sie hier, bis ich komme, Stay here until I come.

3. Adverbial clauses of mode and manner answer to the questions Wie? How? and Auf welche Weise? In which way (manner)? These clauses can be (*a*) comparative, or (*b*) conclusive. In (*a*) the subjects of the principal sentence and of the adverbial clause are compared; in (*b*) a conclusion is drawn in the one from the other.

(*a*) The comparative clause is introduced by the conjunctions wie, als, wie—so, so—so, als daß, als ob, als wenn, wie wenn, indem, ohne daß, je nachdem, je—desto, insofern, inwiefern, insoweit, inwieweit. The similarity of the objects compared is indicated by wie, the superiority or inferiority by als [see LV., 5, 6]: stark wie Eisen, strong as iron; stärker als Eisen, stronger than iron. If the principal sentence and the comparative clause have the same subject and predicate, these can be dropped in the comparative clause after the conjunctions als and wie: Er liebt seine Bücher, wie (er) sonst nichts auf Erden (liebt), He loves his books as he loves nothing else on earth. Comparative clauses introduced by ohne daß can also be contracted if they have the same subject as the principal sentence: Er stimmt zu, ohne daß er darüber ein Wort verliert can be contracted (with omission of daß, and with the prepositional infinitive of the verb) into: Er stimmt zu, ohne darüber ein Wort zu verlieren, He assents, without wasting [losing] a word about it. Comparative clauses introduced by indem are contracted by omission of the conjunction and subject, the verb being put in the participle present: Er stand auf, indem er dem Kellner eine Silbermünze zuwarf, and Er stand auf, dem Kellner eine Silbermünze zuwerfend, He got up, throwing a silver coin to the waiter.

(*b*) Conclusive clauses are introduced by so — daß, sodaß, daß, zu — als daß, etc. Als daß is followed by the subjunctive: Ich war zu erregt, als daß ich ihm hätte antworten können, or contracted (with omission of the conjunction, and with the infinitive with um zu): Ich war zu erregt, um ihm antworten zu können, I was too excited to be able to answer him. Er war zu vorsichtig, als daß er den Rat befolgt hätte, or contracted: Er war zu vorsichtig, um den Rat zu befolgen, He was too cautious to follow the advice. The contracted form is distinctly preferable and is generally employed.

4. Adverbial clauses of cause denote (*a*) the cause, (*b*) the purpose, (*c*) the condition, (*d*) the concession of an action expressed in the principal sentence.

(*a*) Clauses of cause are introduced by the conjunctions weil, indem, da, dadurch — daß, daran — daß, davon — daß, daraus — daß. Examples: Ich ging fort, weil Sie nicht kamen, I went away because you did not come. Da er nichts sagte, sprach auch ich nicht davon, Since he said nothing, I, too, did not speak about it. The clauses of cause introduced by the conjunctions da and weil can be contracted by the omission of the conjunction and the subject, the verb being put in the participle: Da ich mit dieser Bestimmung nicht einverstanden war, brach ich die Verhandlungen ab, As I did not consent to this stipulation, I broke off the negotiations; or contracted: Mit dieser Bedingung nicht einverstanden, brach ich die Verhandlungen ab.

(*b*) Clauses of purpose are introduced by the conjunctions damit, auf daß, daß, etc. (sometimes with the correlatives darum, deshalb, zu diesem Zwecke, in the principal sentence). The verb in these clauses takes the subjunctive mood: Er sprach leise, damit ihn niemand höre, He spoke low, so that no one should hear him. The contraction is effected in the usual way, by omission of conjunction and subject, the verb taking the prepositional infinitive with zu or um zu: Sie scheute keine Mühe, damit sie zu ihm gelange, or Sie scheute keine Mühe, um zu ihm zu gelangen, She shirked no trouble to get to him.

(*c*) Conditional clauses are introduced by falls, wenn, wofern, wo, im Falle daß, sometimes with a correlative so in the principal sentence: Falls es regnet, so komme ich nicht, If it rains I do not come. If the conjunction of the subordinate clause is dropped, the verb must precede the subject: Regnet es, so komme ich nicht. If a clause introduced by wenn is contracted, the conjunction and subject are omitted, and the verb takes the past participle: Wenn er getreten wird, krümmt sich auch der Wurm, or contracted: Getreten, krümmt sich auch der Wurm, Even the worm will turn when trodden on.

(*d*) Clauses of concession are introduced by wenn auch, wenngleich, wenn schon, ob auch, obgleich, obschon, obwohl, wie auch, wiewohl, although, sometimes with a correlative so doch or so dennoch in the principal sentence. The conjunctions wenn, ob, are sometimes dropped for reasons of euphony, in which case the sequence of words is the same as in an independent interrogative sentence: Wenn auch das Unglück ihn tief gebeugt hatte, so ließ er doch den Mut nicht sinken, Although misfortune had bent him down, he did not lose courage; or contracted: Hatte ihn auch das Unglück tief gebeugt, so ließ er doch den Mut nicht sinken.

EXAMINATION PAPER XXIII.

1. To which question does the attributive clause answer, and for what reason?
2. How are relative clauses connected with their principal sentences?
3. What determines the gender and number, and what the case, of the relative pronoun in an attributive clause?
4. When is it necessary to employ the relative pronouns der, die, das; and what consideration decides, in other cases, the alternate use of these pronouns and of welcher, welche, welches?
5. Which relative pronoun must be used, when the relative clause refers to the neuter of an adjective in the superlative? Under what other circumstances is the same pronoun to be used?
6. How can relative clauses be contracted?
7. What are adverbial clauses, and how are they grouped?
8. How is it possible to decide whether dependent clauses introduced by the conjunctions wo, woher, wohin, are adverbial clauses of place or relative (attributive) clauses?
9. What is the difference between an adverbial clause of place and a mere adverbial phrase of place?
10. What tenses are used in the principal sentence and in the adverbial clause of time (*a*) if the actions of both coincide, (*b*) if the action of the dependent clause precedes that of the principal sentence?
11. What rule determines the use of wie and als in comparative clauses?
12. How can a comparative clause be contracted? And how are clauses of cause, purpose, and condition contracted?

EXERCISE 1 (*a*). Insert the missing relative pronouns:

Ich kaufte den Hut in dem Geschäfte, ... sich nebenan befindet.
I bought the hat in the shop [which is] next door.
Dies widerfuhr mir, ... doch den Weg genau kannte.
This happened to me who knew the way exactly.
Er stellte mir seine Frau vor, ... ich vorher noch nie gesehen hatte.
He introduced to me his wife whom I had never seen before.
Dies ist der Mann .... Sohn uns hierher führte.
This is the man whose son conducted us here.
Dies ist die Bäuerin, ... Tochter uns den Weg gezeigt hatte.
This is the peasant-woman whose daughter had shown us the way.
Das war Alles, ... ich erfahren konnte.
This was all I could learn.
Das sagen Sie, ... dies doch besser wissen sollte?
You say so, who ought to know better?
Das sagte der Mann, ... dies hätte besser wissen müssen.
The man said so, who should have known better.
Das Klügste, ... wir tun können, ist, abzureisen.
The best [wisest] we can do, is to depart.
Es gab nichts, ... er nicht wußte.
There was nothing that he did not know.

(*b*). Form attributive (relative) clauses of the following sentences :

Ich kaufte den Hut in dem nebenan befindlichen Geschäfte.
I bought the hat in the shop next door.
(See first sentence of exercise 1*a*.)

Alle daran gewandte Mühe war vergeblich.
All the trouble spent on it was wasted.

Ich befolgte den mir erteilten Rat. Sie
I followed the advice given to me. She
schenkte ihm eine wunderbar duftende Rose.
presented him with a deliciously smelling rose.

Er zeigte mir den kürzesten Weg.
He showed me the shortest way.

EXERCISE 2. Insert the correct conjunctions of comparison :

Ich fühle mich so wohl, ... ein Fisch im Wasser.
I feel as well as a fish in the water.
Ich fühle mich wohler, ... ein Fisch im Wasser.
I feel better than a fish in the water.
. . . . die Sonne aus den Wolken bricht, so
As the sun breaks forth from the clouds, so
trat die Fee aus dem Waldesdunkel hervor.
the fairy stepped out of the darkness of the forest.
Unser Garten ist weit schöner . . . . der seine.
Our garden is far more beautiful than his.
Er liebte ihn, ... ein Bruder den andern [liebt].
He loved him as one brother loves the other.

KEY TO EXERCISE IN EXAMINATION PAPER PAGE 4076

Dem Kinde wurde befohlen, im Zimmer zu bleiben. Dem Kinde wurde befohlen dazu bleiben. Ich bat ihn mir zu helfen. Ich bat ihn mir mit einigem Gelde auszuhelfen. Ich bat ihn sich einstweilen ohne mich zu behelfen. Er erklärte nichts davon zu wissen, or: Er erklärte, er wisse nichts davon. Der Vater fürchtete, sein Sohn würde ihm nichts mitteilen. Ich hoffe morgen früh abzureisen, or: Ich hoffe, ich werde morgen früh abreisen. Es war, sagte er mir, schrecklich. Der König wurde, berichtete die Zeitung, glänzend empfangen. Den Truppen wurde der Befehl erteilt das Feuer zu eröffnen. Gestatten Sie mir Ihnen alles zu erzählen. Erlauben Sie mir Sie nächstens zu besuchen. Gewiß, aber trachten Sie den Zug nicht zu versäumen. Verhält es sich so, dann bleibe ich noch. Wünschen Sie es nicht, so wird es einfach nicht geschehen.

CONVERSATIONAL EXERCISES

IX. Forms of Courtesy

Generally speaking, the Germans are far more formal and courteous in conversation than the English, and have many expressions and quaint forms of speech which do not exist in English. Thus it is customary to say „Guten Appetit" (good appetite) before, and „Wünsche wohl gespeist zu haben" (I hope you have dined well) after a meal; or to exclaim „Zum Wohlsein!" on hearing somebody sneeze. The custom of addressing people by their full title is carried to such extremes that the wife of a small government official is addressed by her husband's title: „Frau Steuereinnehmerin" (Mrs. tax-collector). To make these forms clearly intelligible, they are here literally translated.

Good-morning! Good-day! Good-evening!	Guten Morgen! Guten Tag! Guten Abend!
How do you do?	Wie geht es Ihnen?
Quite well, thank you; and you?	Danke bestens, ganz gut; und Ihnen?
Well, not particularly well; I have caught a slight cold.	Nun, nicht zum Besten; ich habe mich ein wenig erkältet.
Good-bye! God be with you!	Adieu! Gott befohlen! Gott zum Gruße!
After you!	Nach Ihnen!
Your health!	Prosit! Auf Ihr Wohl! Ihre Gesundheit!
Farewell!	Leben Sie wohl!
May we meet again soon!	Auf Wiedersehen!
Good-night [gracious] madam!	Gute Nacht, gnädige Frau!
I am pleased to have made your acquaintance.	Es hat mich gefreut, Sie kennen zu lernen, (or: Ihre werte Bekanntschaft zu machen).

X. Concerning Time

What o'clock is it?	Wie viel Uhr (wie spät) ist es?
Eight o'clock. A quarter past eight. A quarter to nine. Five minutes past nine. Half past eleven.	Acht Uhr. Ein Viertel nach acht Uhr. Dreiviertel neun Uhr. Fünf Minuten nach neun. Halb zwölf Uhr.
The train leaves at 2.20, at 3.30 p.m.	Der Zug geht um 2 Uhr 20 Minuten, um halb vier nachmittags ab.
The fast train arrives at 4.45 a.m.	Der Schnellzug kommt um dreiviertel fünf Uhr morgens an.
I shall be with you at five minutes to six.	Fünf Minuten vor sechs Uhr bin ich bei Ihnen.
I shall only wait for you till a quarter past six, then I shall go, as the performance begins at 7 o'clock sharp.	Ich warte nur bis ein Viertel nach sechs auf Sie, dann gehe ich fort, da die Theatervorstellung um präcise 7 Uhr beginnt.

XI. Concerning Relationship

That young lady is a niece of the officer who travelled with us.	Jenes Fräulein ist eine Nichte des Offiziers, der mit uns reiste.
My nephew lived twelve months with his mother in London.	Mein Neffe lebte ein Jahr lang mit seiner Mutter in London.
I have a cousin at Breslau and an uncle at Magdeburg.	Ich habe einen Vetter in Breslau und einen Onkel in Magdeburg.

I think there were several brothers and sisters; has the child any brothers or sisters?	Ich glaube es waren mehrere Brüder und Schwestern da; hat das Kind Geschwister?
The grandparents took charge of the little girl.	Die Großeltern nahmen die Kleine zu sich.
How many grandchildren has the Count?	Wie viel Enkel hat der Graf?
He is a stepbrother of my brother-in-law.	Er ist ein Stiefbruder meines Schwagers.
Do you know my sister-in-law?	Kennen Sie meine Schwägerin?
The bridegroom and the bride came to see us.	Der Bräutigam und die Braut machten uns einen Besuch.
The children are twin-sisters.	Die Kinder sind Zwillingsschwestern.

Continued

SPANISH

By Amalia de Alberti & H. S. Duncan

VERBS—continued

The Reflexive Verb. Reflexive verbs are so called because they are conjugated with a pronoun object identical with the subject. Examples:

alabarse, to praise oneself
me alabo, I praise myself
te alabas, thou praisest thyself
se alaba, he praises himself
nos alabámos, we praise ourselves
os alabais, you praise yourselves
se alaban, they praise themselves, etc.

Many neuter and passive verbs have only the reflexive form in Spanish. Examples:

alegrarse, to rejoice
arrepentirse, to repent
quejarse, to complain
burlarse, to mock
enfadarse, to get angry
levantarse, to get up
acostarse, to go to bed
llamarse, to be called

Verbs having only the reflexive form in Spanish, when active or neuter in English, may be conjugated with *se*, itself, and the dative pronoun to distinguish the person. Examples:

me alegro, or *se me alegra*, I rejoice
te alegras, or *se te alegra*, thou rejoicest
se alegra, or *se le alegra*, he rejoices
nos alegrámos, or *se nos alegra*, we rejoice
os alegrais, or *se os alegra*, you rejoice
se alegran, or *se les alegra*, they rejoice

Reciprocal Verbs. When reflexive verbs in the plural refer to two or more persons separately they are called reciprocal, and the pronoun object is rendered by *each other* when two are intended and *one another* when several are indicated. Example: *se aman*, they love each other, or one another.

As *se aman* may also mean they love themselves, when any doubt is possible such phrases may be strengthened by some addition. Examples:

se aman á si mismos, they love themselves
se aman el uno al otro, they love each other
se aman los unos á los otros, they love one another.

The Passive Voice. The passive voice, as already explained, is formed by the simple and compound tenses of the auxiliary verb *ser* joined to the past participle of the verb to be. Examples:

soy amado, I am loved
fui amado, I was loved
seré amado, I shall be loved
haber sido amado, to have been loved

The passive voice is little used in modern Spanish, but is generally replaced by the reflexive construction. Example:

El libro se vendió muy barato, The book was sold very cheap; rather than *fué vendido*.

The passive voice is preferred in narrative of past events. Example:

Muchos soldados fueron matados en la batalla, Many soldiers were slain in the battle.

The Participle. The past participle is looked upon as an adjective, and agrees with the noun in gender and number when used as an adjective without the verb, and when conjugated with any verb as auxiliary except *haber*. With *haber* the participle is always invariable. Examples:

Ellos han leido las cartas, They have read the letters.

Las cartas están leidas, The letters are read.

Las cartas leidas, The letters read.

Participles are considered irregular when they do not end in *ado* or *ido*, according to their conjugation.

The following regular verbs have an irregular past participle:

Infinitive	*Participle*
abrir, to open	*abierto*, opened
cubrir, to cover	*cubierto*, covered
escriber, to write	*escrito*, written
imprimir, to print	*impreso*, printed

All the derivatives of the above verbs have the same irregularity. Examples:

descubrir, to discover	*descubierto*, discovered
encubrir, to conceal	*encubierto*, concealed
inscribir, to register	*inscrito*, registered

Impersonal Verbs. Impersonal verbs are those which can only be used in the third person singular, and whose subject in English is *it*. They are inflected according to their conjugation. True impersonal verbs refer to natural phenomena. Examples:

llover, to rain	*llueve*, it rains
nevar, to snow	*nieva*, it snows
helar, to freeze	*hiela*, it freezes
tronar, to thunder	*truena*, it thunders
amanecer, to dawn	*amanece*, it dawns
anochecer, to grow dark	*anochese*, it grows dark

The two last may be used personally. Examples:

Amanecí en Londres, I reached London at dawn.

Anochecimos en Paris, We reached Paris at nightfall.

The following are examples of the different methods of rendering the English impersonal "it is" in Spanish:

Es verdad, It is true	*Hace frio,* It is cold
Así es, It is so	*Hace sol,* It is sunny
Está helando, It is freezing	*Hace tres dias,* It is three days ago

Hay diez millas de aquí, It is three miles from here.

Mas vale tener poco que nada, It is better to have little than nothing.

NOTE. *Hace* is always used with reference to time, and *hay* with reference to distance.

Vocabulary	Vocabulario	Vocabulary	Vocabulario
A cowherd	Un vaquero	A bag-pipe	Una gaita
A watering-pot	Una regadera	A fife	Un pifano
A spade	Una azada	A clarion	Un clarin
Shears	(Las) cizallas	A spring	Un manantial
A shearer	Un esquilador	A torrent	Un torrente
A thrashing-machine	Una maquina de trillar	A rivulet	Un arroyo
A cornrick	Una hacina de trigo	A canal	Un canal
A seed-plot	Un semillero	The calm	La calma
A footpath	Una senda	The storm	La tempestad
A billiard-table	Una mesa de billar	A horseman	Un jinete
The balls	Las bolas	A horse	Un caballo
A game of chess	Un juego de ajedrez	The reins	Las riendas
A game of draughts	Un juego de damas	The bit	El freno
A draught-board	Un tablero de damas	The curb	La barbada
A dice-box	Un cubilete	The spurs	Las espue'as
A pawn	Un peon	The girth	Las cinchas
The bowling-green	El boleo	The saddle	La silla
Horse races	Carrera de caballos	The stirrups	Los estribos
The fishing, fishery	La pesca	The horse-cloth	La gualdrapa
Fencing	La esgrima	The capariso	El caparazon
To smoke	Fumar	To break a horse	Domar un caballo
A cigar	Un cigarro	The horse-breaker, trainer	El domador
A Havana	Un habano	To saddle a horse	Aparejar
A cigarette	Un cigarrillo	The harness	El aparejo
Tobacco	Tabaco	To trot	Trotar
Tobacconist	Tabaquero	To amble	Amblar
A pipe	Una pip	To gallop	Galopar
A blunderbuss	Un trabuco	Forage	Forraje
A harp	Una arpa	Oats	Avena
A flute	Una flauta	Corn	Grano
		Hay	Heno
		Bran	Afrecho
		The engagement	El compromiso

EXERCISE XIV. (1)

Translate the following into Spanish:

1. Will you play chess? I cannot play as well as you. It does not matter, I will give you the queen and pawn.
2. Very good; but after finishing a game of chess we will play one of draughts. I think I know that game very well. Here is the board.
3. Take a cigar; they are good; they are Havanas. Thanks, I do not smoke. And your brother, [does he] smoke? My brother smokes cigars, cigarettes, and a pipe.
4. The Scotch play the bagpipes, and they are the only [people] in the world who can play them.
5. This water you see here is a spring of fresh water.
6. This is a rivulet in summer, and a voluminous river in the winter.
7. Calm comes before a storm.
8. He says he is a good horseman and he cannot manage his horse.
9. Do you use spurs? Never.
10. This saddle is old. You should buy a new one; and allow me to tell you that the stirrups are too long.
11. This horse is very spirited; it must be broken in. That is easy, I have a good trainer in my stables.
12. The harnessing will be quickly done.
13. It is not well to praise oneself so much, as he who praises himself runs risk of being mocked.
14. Let them mock; I do not care!
15. My heart rejoices at the sight of you.
16. We are very pleased at your good fortune.

EXERCISE XIV. (2)

Translate the following into English:

1. La guerra fué muy sangrienta; murieron muchos soldados.
2. Al recibir la triste noticia la pobre mujer se desmayó.
3. ¿ Puedo abrir esa carta? Está abierta desde esta mañana.
4. El cielo está encapotado; se deben cubrir esas flores, pues de seguro lloverá.
5. He escrito á su señor padre dándole parte de nuestro compromiso; verémos si se digna escribir.
6. ¡ Esas palabras están impresas en mi corazon!
7. Hay que imprimir este manuscrito.
8. La América fué descubierta por Colón.
9. Al descubrir la estátua, la derribáron al suelo.
10. Truena, llueve y hiela al mismo tiempo.
11. ¡ Vá á tronar!
12. Al amanecer salimos del pueblo incognito.
13. Amanece á las cinco de la mañana.
14. Al anochecer llegamos á nuestro destino; fué una jornada larga.
15. ¿ Es verdad que hay doce millas de aqui á San Juan de Luz?

PROSE EXTRACT XII.

Passages from an Essay by Mariano José de Larra, entitled "¿ Quién es el Público ?" (Who is the Public ?).

This word public which is always in every man's mouth in support of his opinions, this accommodating servant of every party and every opinion, is it a word void of meaning or is it a real and actual living being? According to the amount of talk there is about it, according to the prominent part it plays in the world, according to the titles lavished upon it, and the consideration	Esa voz pública que todos traen en boca siempre en apoyo de sus opiniones, ese comodin de todos los partidos, de todos los pareceres, ¿ es una palabra vacia de sentido, ó es un ente real y efectivo? Segun lo mucho que se habla de él, segun el papelon que hace en el mundo, segun los epitetos que se le prodigan, y las consideraciones que se le guardan, parece que debe de ser alguien.

shown it, it seems as if it ought to be somebody. The public is enlightened, the public is indulgent, the public is impartial, the public is respectable, there can be no doubt, therefore, that the public exists. Such being the case, who is the public and where is it to be found?

El público es ilustrado, el público es indulgente, el público es imparcial, el público es respetable: no hay duda, pues, en que existe el público. En este supuesto, ¿ Quien es el público y donde se le encuentra ?

With a youthful and ingenuous countenance I leave my house to search for the public in these streets, and to take notes in my pocket-book of the character, or rather of the distinctive characteristics of this worthy gentleman. . . . .

Salgome de casa con mi cara infantil y bobalicona á buscar al público por esas calles, y á tomar apuntaciones en mi registro acerca del caracter, por mejor decir, de los caracteres distintivos de ese respetable señor. . . .

I gather up my notes more perplexed than ever as regards the object of my inquiries, and seek information from persons more learned than myself. To my question "Who is the public ?" an author who has been hissed replies, "Ask me rather how many fools are required to make a public."

Reuno mis notas y más confuso que antes acerca del objeto de mis pesquisas, llego a informarme de personas más ilustradas que yo. Un autor silbado me dice cuando le pregunto, "¿ Quién es el público?" "Preguntadme más bien cuántos necios se necesitan para componer un público."

An author who has been applauded replies, "It is the assembly of enlightened persons who decide upon the merit of literary productions in the theatre."

Un autor aplaudido me responde, "Es la reunion de personas ilustradas que deciden en el teatro del mérito de las producciones literarias."

Mariano José de Larra (1809-1837) was born with all the gifts of genius, marred by a bitter pessimism which drove him to suicide at the age of twenty-eight. He was the author of one historical novel and a few adaptations for the stage, but his fame rests chiefly upon the vigorous prose of his satirical essays, which appeared under a variety of pseudonyms. In spite of his early death he is considered one of the foremost authors of the century.

Mariano José de Larra (1809-1837) nació con todos los dones de un genio, dañados por sus sentimientos pesimistos que lo llevaron al suicidio á la edad de veinte y ocho años. Fué el autor de una novela historica, y de algunas adaptaciones para las tablas, pero su fama está principalmente basada sobre la prosa vigorosa de sus ensayos satiricos, los cuales parecieron bajo varios seudónimos. Apesar de su temprana muerte está considerado como uno de los primeros autores del siglo.

Key to Exercise XIII. (1)

1. ¿ Desde cuando tiene el señor banquero M...... la cruz de . . . . ?
2. Le fué conferida despues de la guerra.
3. Me alegraré desmentir los rumores falsos que han corrido por la ciudad.
4. Fué herido de un pistoletazo en el brazo derecho.
5. ¿ Fué el derecho, ó el izquierdo ?
6. Ya he dicho que era el derecho.
7. Inferí que estaba malo, no le he visto por muchos dias.
8. Ese hombre es capaz de pervertir á la persona más sabia, sus doctrinas son escandalosas.
9. ¡ Vamos á la feria ! de seguro que podremos comprar buenos potros y caballos.
10. El salonde fumar está al fin del jardin.
11. Iremos mañana á la fundicion de cañones.
12. El ladron con la ganzúa abrió la puerta.
13. El centinela está en la garita.
14. Tiene Vd bastantes uvas para hacer la vendimia. No, no tengo bastantes, pero tengo hermosos racimos.
15. ¿ Tiene Vd viñas ? Tengo dos, una en Moguer y otra en Jerez.
16. El eje se rompió cuando los caballos iban al galope y el coche volcó.
17. Se representa á la muerte con una guadaña y un reloj de arena.
18. Los segadores tienen la supersticion de si al segar cortan algun animal, sea pájaro, conejo ó cualquier cosa animada, que han cortado su vida.
19. Despues de concluida la cosecha los segadores bailan en la era, es una costumbre que data de la edad media.
20. La fuente del jardin es de mármol y el agua muy limpia.

Key to Exercise XIII. (2)

1. I come to inquire into the details of the theft which took place yesterday.
2. We can say no more than what we have said already.
3. It would be possible to catch the thieves if we made haste.
4. It is not worth the trouble; what they took is of little value, and, after all, "live and let live" comes in well here.
5. He is a man of strong will, he has risen from nothing, and look at the position he holds ; think of all the difficulties he has had to conquer.
6. He is very distinguished.
7. Let us go to catch the train. It is late, and if you do not arrive in time you will not catch it.
8. Be careful; thou art scattering that seed, and there will be none left for the garden.
9. That woman is very frivolous and superficial.
10. Last night we went to the gallery of the "Theatre Royal." I did not like the tragedy ; the leading lady is too old, and the leading man cannot declaim.

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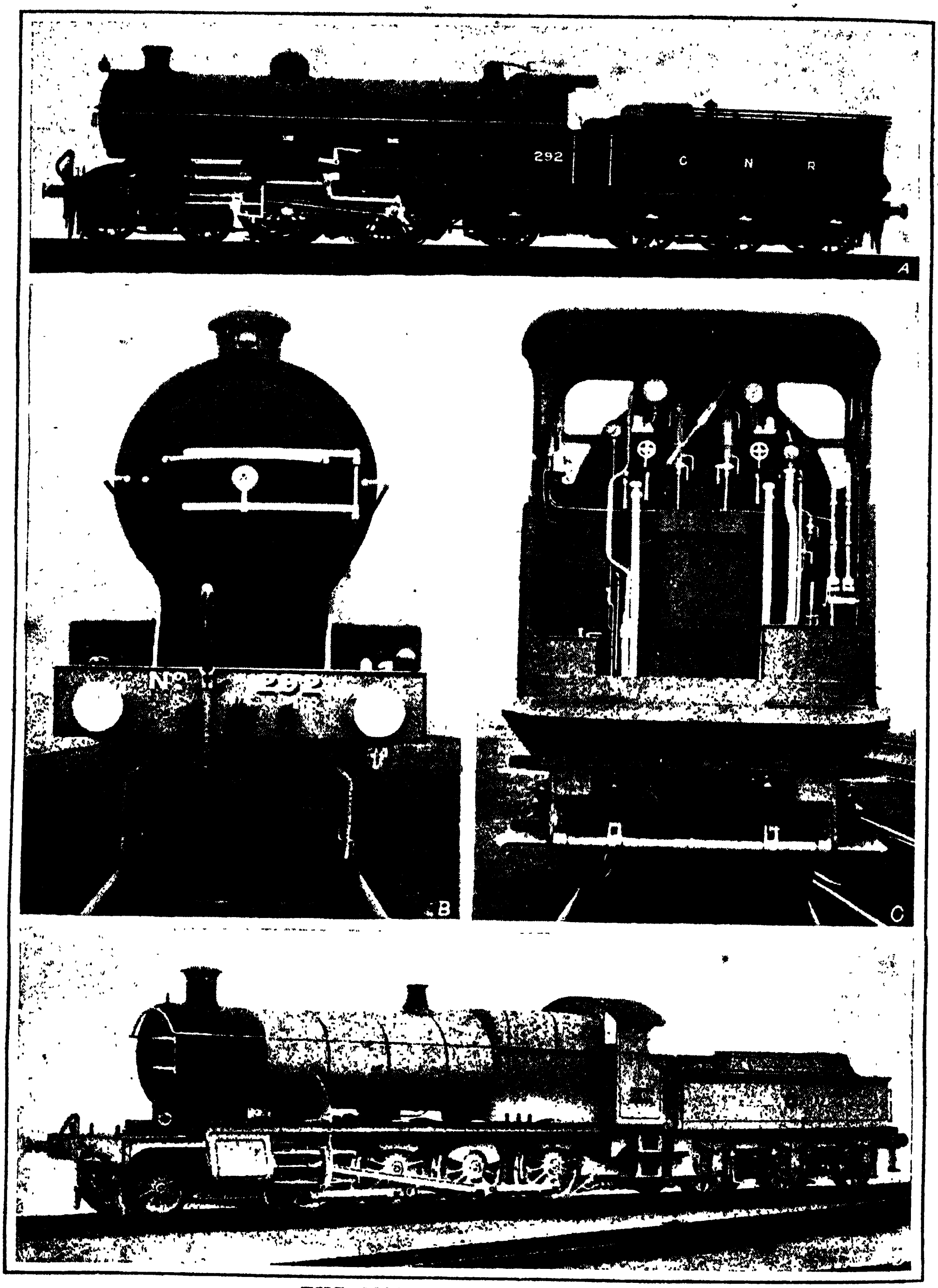


THE MODERN LOCOMOTIVE

A. Four-cylinder compound "Atlantic" type express locomotive, G. N. R., built at Doncaster works, to the designs of Mr. H. A. Ivatt. There are two high-pressure cylinders outside the frames, and two low-pressure cylinders inside. B. End view of same, showing smoke-box. C. End view of same, showing the fire-box, interior of cab, and controlling gear, injectors, etc. D. "Consolidation" type (2—8—0) mineral locomotive, G.W.R., built at Swindon works, to the designs of Mr. J. G. Churchward

RAILWAY MANAGEMENT

Division of the Railway Administrative Staff into its Several Departments, and the Responsibilities of Each

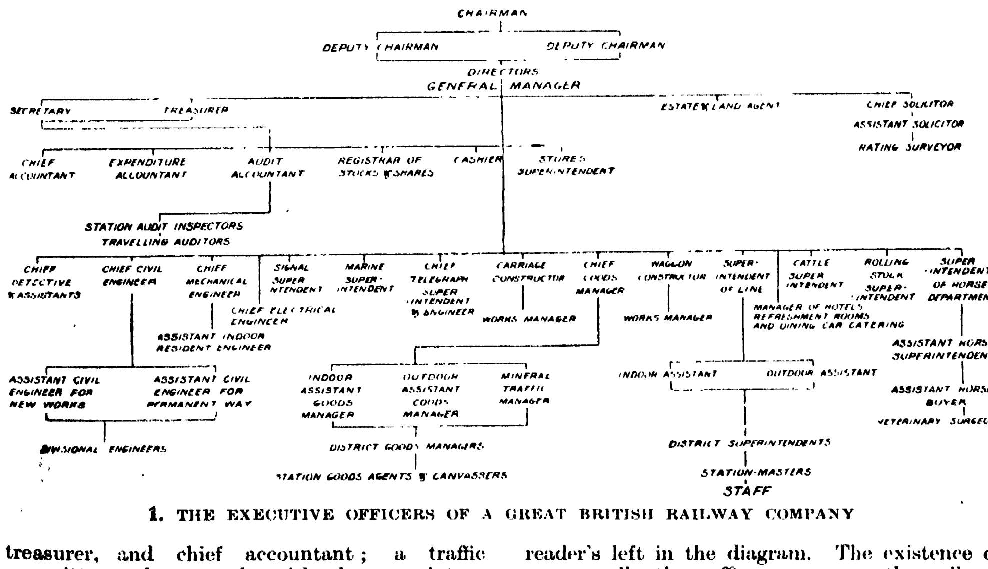
Continued from page 4189

By H. G. ARCHER

THE policy and administration of a British railway company is vested in a board of directors, presided over by a chairman and two or more deputy chairmen. The directors are elected by the shareholders. A certain number of directors retire annually or semi-annually, but are eligible for re-election. Any shareholder, provided that he possesses the qualification of holding a specified amount of ordinary stock, is eligible for a directorship. Besides electing their directors, shareholders also elect the auditors of the company. The full board of directors, as a general rule, meets once a month; but there is a number of directorial committees whose members confer together, and with the managerial chief or chiefs of the particular department which the latter represent, at more frequent intervals. For example, there is a finance committee, in close touch with the secretary, treasurer, and chief accountant; a traffic committee, who consult with the superintendent of the line and chief goods manager; and a locomotive committee, who associate themselves with the chief mechanical engineer, or locomotive superintendent: together with Parliamentary, Fares and Rates, Debts and Goods claims, Hotels, Docks and Steamboats committees, etc.

The General Manager. The responsible officer for the whole executive administration of a railway is the general manager. He acts as "chief of the Staff" to the entire undertaking, and although, of course, it is not practicable for him to supervise personally the actions of every employé, he is accounted the connecting link in the chain of responsibility between the board and the lately-joined lad porter. General managers have been known to rise to their pre-eminent position from very subordinate grades of the staff. No particular branch of the railway service can be earmarked as holding the ladder of success. True, the majority of general managers have mounted its rungs through the traffic department; but there are many instances of locomotive superintendents, engineers, and representatives of the Legal Department having attained the "blue ribbon" of the railway service.

Administrative Departments. The various administrative departments of a great railway company are best explained by diagram [1]. The statutory officers are scheduled on the reader's left in the diagram. The existence of any or all other officers concerns the railway companies alone. Parliament in passing railway Bills realises the need of a secretary and treasurer only (although the posts may be combined by one individual), the former to keep the records and registers, and the latter to be responsible for the cash.



1. THE EXECUTIVE OFFICERS OF A GREAT BRITISH RAILWAY COMPANY

The general duties of these statutory officers are clearly defined. The secretary attends all board meetings, and makes record of the business done. He signs and issues stock certificates and transfers of every kind, executes mortgage bonds, agreements, and all manner of deeds, and

his name often appears at the foot of the company's advertisements for tenders, notices of shareholders' meetings, and schedules of the bylaws exhibited for public information. The secretary, in short, is the legal representative of a railway company, while in most matters of policy, and in all those of finance, he is the advisor as well as recorder. Secretaries are the diplomatists of the railway service. In some instances, a secretary combines the duties of treasurer; but with the great companies the treasurer's is a separate department, which is subdivided, as shown in the diagram.

The Treasurer. The treasurer controls the management, collection, and expenditure of the company's revenue and is responsible for all the incoming and outgoing moneys to both the shareholders and the State; therefore, he must be supplied with the most detailed information regarding receipts and expenditure from every source, together with detailed statements of the company's liabilities. His right-hand men are a chief accountant, an expenditure accountant, an audit accountant, a registrar of stocks and shares, and a chief cashier.

Besides keeping and checking the accounts, the treasurer is charged with the preparation of all financial statistics required by the Board of Trade, statements furnished to the assessor of railways for valuation roll purposes, and those supplied to the Income Tax Commissioners—in short, all statements which in any way affect the financial concerns of the company. The departmental staff of the chief accountant of a great railway company, whose half-yearly balance-sheet runs into several millions of pounds, is a vast organisation of itself. It comprises scores of travelling auditors and bookkeepers, and a regular army of clerks engaged in recording and checking numberless financial transactions.

Railway Revenue. A railway company's revenue is derived from a variety of sources. The primary business of a railway is the transportation by rail (1) of passengers, (2) of goods. Under the receipts from passenger traffic are included not only the fares paid by ordinary passengers and season-ticket holders, but also the money paid for the conveyance of excess luggage, mails, parcels, carriages, horses, dogs, etc. Goods traffic receipts comprise the payments made for the transport of minerals, general merchandise, and livestock.

In addition to the above traffic receipts a railway company enjoys a large revenue from miscellaneous sources—such as steamboats, canals, docks, house rents, tolls, hotels, refreshment catering, etc. A remarkable feature of British railways is the large amount of capital sunk in steamboats, docks, hotels, etc., and the large amount of money spent on purposes entirely outside the working of trains. The companies which indulge most in these "side shows," as they are termed, are the Midland, the Great Central, and the London and South-Western. At present there is a strong predelection on the part of railway companies either to buy up existing docks, or to build new ones, and to establish fleets of cross-channel passenger and cargo steamers. The Great Northern furnishes the most striking instance of a railway company which has always steadily adhered to the principle of confining its business, as far as possible, to traffic by rail.

Stores Department. The stores department forms the commercial arm of the service. It is said of the chief storekeeper that he is the only railway officer whose principal qualification is that of a merchant; yet, while he needs no special railway service, he can be trained nowhere else. In the stores every conceivable requisite for railway working is found in stock, from the rails, sleepers, and chairs for the permanent way and the fuel and oil for the locomotive, down to the sponge cloths used in cleaning, the tools with which all repairs are executed, and the soap and towels which the passenger finds in a lavatory. All departments are dependent upon the storekeeper's vigilance and readiness. He has to be a specialist buyer of everything, at one moment bargaining with a steelmaster for rails, at another with a clothier for the supply of cloths for guards' and porters' uniforms. Then, he has closely to observe the daily prices of all commodities that fluctuate, so as to place contracts in the cheapest market. When he has completed his contracts he must see that the goods are supplied in the quantities ordered, and subject the latter to tests for quality. After this, he is responsible that they are distributed throughout the system where they are likely to be wanted, and can be got at without delay. But he not only buys and distributes, he also sells all old or worn-out materials—sleepers, telegraph posts and wires, rolling stock, fittings, etc.—again watching the market to judge of the best time for disposing.

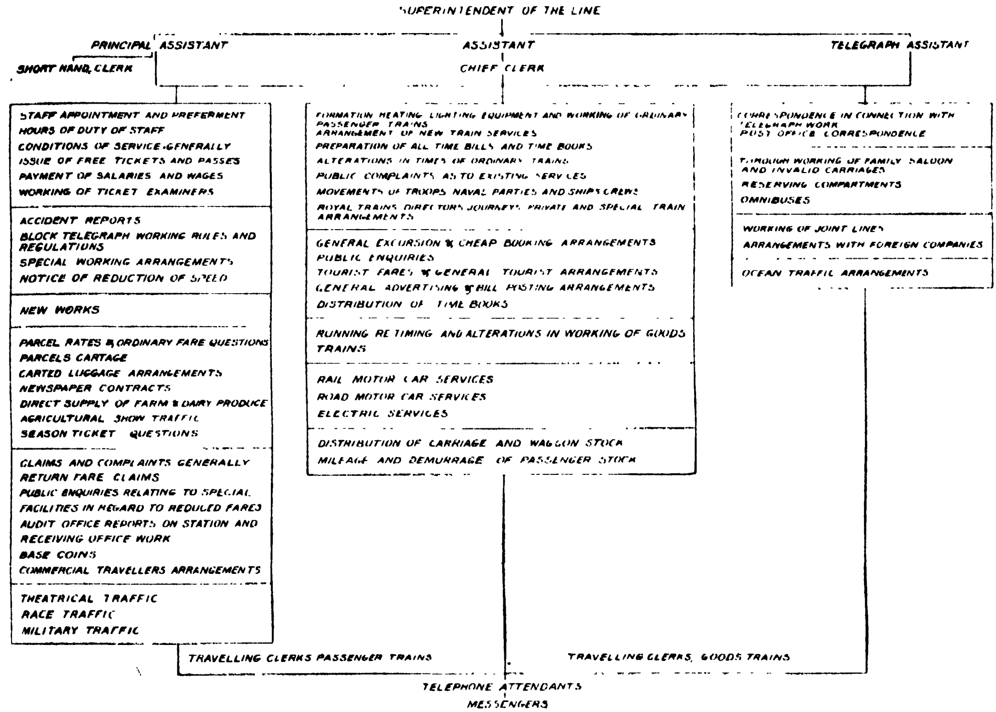
The Legal Department. Every important railway company has its own legal department. The chief solicitor is the directors' principal legal adviser on matters of policy, and he or his qualified assistants are at all times accessible to the officers of every department. The legal department is, as a general rule, pretty sharply divided between a staff of assistant solicitors for Parliamentary work; another staff of assistants experienced in conveyancing, in respect of the company's landed interests; and another staff learned in Common Law, who deal with the constant crop of matters in connection with claims, outstanding accounts, demurrage, and prosecutions for breaches of bylaws, and frauds.

The Traffic Department. The normal organisation of a British railway company furnishes the general manager, as head of the traffic department, with two trusty lieutenants in the persons of a chief goods manager, and a superintendent of the line. The first-named has two assistants, one for outdoor working, and another for the indoor, including the making of rates, while occasionally a third assistant —a mineral traffic manager—is added. The

superintendent of the line deals with the working of the trains, both goods and passenger, and controls every factor pertaining to the movement of the traffic, except the supply of the necessary locomotive power.

It is impossible to consider the working of the passenger traffic altogether apart from that of traffic, and all traffic carried by passenger trains, termed "coaching traffic."

How vast and far-reaching in its scope is the organisation of the superintendent of the line's department may be judged from the accompanying diagram [2]. For the commercial administration of the goods and mineral department,



2. TYPICAL ARRANGEMENT OF STAFF AND DUTIES—OFFICE OF SUPERINTENDENT OF THE LINE

the goods, as every kind of train has to be accommodated to a great extent upon the same lines of rails.

Superintendent of the Line. Therefore, the superintendent of the line is the absolute head of everything connected with the movement and handling of the trains, both passenger and goods, and is in charge of all stations, except big goods yards. His operative duties are as follows: the control of every individual in the traffic department, including the shunting staff, responsibility for providing a sufficient service of passenger and goods trains, and for their economical working, for the safety of the working, and for the staffing of the trains. Then, the preparation of the time-tables, both public and working, and all matters concerned with the appointment, supervision, and promotion of the traffic staff are in his hands. Further, he travels with and takes charge of Royal and other extra-special trains. But his duties are not confined to the operative side of the traffic working. He is also responsible for the commercial side of the passenger traffic—that is, the securing and charging for ordinary passenger and excursion the entire railway system is divided into districts, under district goods managers, each of whom has a station agent (who is of equal rank with the stationmaster) and a town agent, together with a staff of canvassers, clerks, foremen, checkers, loaders, carmen, etc. However, in less important districts, it may be possible to dispense with the services of a district goods manager, in which case the district superintendent becomes responsible for both passenger and goods working. Likewise, at small stations, the stationmaster acts as goods agent as well.

At stated intervals, "officers' conferences" are held at the company's general offices. These conferences are attended by the chief officers at headquarters, and by the whole body of district traffic superintendents and district goods managers. But the conferences are kept distinct—namely, traffic and goods, with the general manager presiding over each.

New System of Organisation. As already stated, the foregoing is the normal organisation; but certain companies have recently struck out a fresh line, which closely follows the American practice. With the old system of organisation, it is alleged that the

functions of the goods managers and district superintendents overlap one another at several points, and that the superintendent of the line's department is handicapped in the efficient plan-making and discharge of its technical duties for the economical handling of traffic by reason of its incorporating such essentially commercial features as parcels, advertising, canvassing, etc., and being burdened throughout with an excess of office work. The new idea is to effect a complete severance of the commercial and operating branches throughout the traffic department. In the beginning of 1902, the North-Eastern Railway reorganised its traffic management on these lines, and the Great Northern Railway soon followed suit. The following is a *précis* of the new arrangement. There are three chief officers—*viz.* :

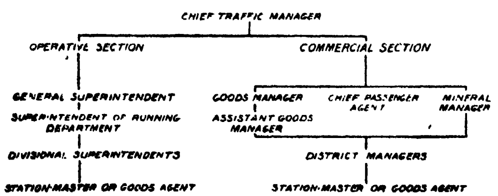
1. The *general superintendent*, who is charged with the movement and handling of traffic everywhere, and in every shape or form ; and supervising the use of the company's telegraphs and telephones.

2. The *chief goods manager*, who is charged with the administration of the department of the company's business connected with the securing and charging for merchandise, livestock, and mineral traffic.

3. The *chief passenger agent*, who is charged with the administration of the department of the company's business connected with the securing and charging for all ordinary passenger and excursion traffic, and all traffic carried by passenger trains termed "coaching traffic"; preparing, printing, and issuing tickets ; advising the general superintendent as to the needs of the train service ; collecting and distributing information as to trade movements and developments ; supervising and controlling the booking and parcels office.

Subordinate Officials. These three officers are responsible to a general traffic manager, and each has an organisation of subordinates, giving a carefully arranged system of devolution. Thus, with the North-Eastern Railway, the general superintendent has three divisional superintendents, below whom come nine district superintendents. The chief goods manager has six district goods managers, and to the chief passenger agent are allotted three district passenger agents.

With the Great Northern Railway, the arrangement is precisely the same, save that the general superintendent is assisted by a high official, known as the superintendent of the running department.



3. DIVISION OF OPERATING AND COMMERCIAL DEPARTMENTS IN THE TRAFFIC DEPARTMENT OF THE GREAT NORTHERN RAILWAY

Superintendent of Running Department. The duties in connection with the section under the immediate control of the superintendent of the running department are as follow :

1. Selects and controls yard and platform inspectors, foremen, guards, brakesmen, signalmen, and shunters, employed exclusively in the running or working of trains.

2. Arranges and controls the working of all passenger, goods, and mineral trains, and of all shunting in yards.

3. Arranges with rolling stock controller as to provision of carriages, waggons, and sheets required for working the traffic.

4. Arranges working of all dining cars.

5. Arranges with locomotive department regarding engines required for traffic purposes.

6. Arranges with signal inspector regarding ordinary matters of traffic working ; proposals for alterations of, and additions to, lines, stations, sidings, etc., and other special matters to be submitted through general superintendent.

7. Controls fog-signalling arrangements.

8. Reports upon all accidents, including cases of injury to passengers, employees, horses, cattle, and livestock.

9. Deals with cases of damage to rolling stock.

10. Supervises the cleaning of all rolling stock, also of cattle-pens.

11. Prepares and issues working and public time-tables and all notices with regard to the proper and safe working of the line.

12. Deals with correspondence from the public relating to the working of trains.

Clerical Staff. As a principle, the supervision and control of the clerical staff, together with the cartage arrangements in the provinces, fall to the commercial section, and that of the outdoor staff, including the staff employed in the goods sheds and warehouses, to the operating section. Exception is made, however, in the case of clerks whose duties are confined entirely to matter connected with the operating section and any members of the uniform staff specially employed in the commercial section.

Engineering Department. The chief (civil) engineer is at the head of two important branches—namely, one for maintenance of existing lines and works, and one for construction of new works. His assistant engineer, for maintenance of permanent way and existing works, has under him a quota of divisional engineers, and, if necessary, a canal engineer as well, while the subordinates of the former are the district engineers, draughtsmen, chief inspectors, sub-inspectors, foremen gangers, and platelayers, and relayers, artificers, carpenters, masons, etc., with their respective foremen. It may be added that when platelayers are engaged in fog-signalling, they pass under the jurisdiction of the traffic department, as represented by the superintendent of the line. His second assistant, the engineer for new lines and works, takes charge of operations once the plans have been prepared by the chief engineer, or, if the services of a consulting engineer should have been requisitioned,

have been approved of by the latter. He has under him resident engineers, who, as the name implies, supervise operations on the spot, and are provided with assistants and draughtsmen. As a rule, the construction of a heavy length of line, harbour, or large station works, etc., is entrusted to a contractor, who carries out his task under the superintendence of the company's engineer for new works.

Locomotive Superintendents. We now pass on to the locomotive superintendent, whose duties embrace the designing and building of suitable locomotives for the various classes of traffic—for instance, express passenger, goods, suburban, "mixed," etc.—the maintenance and repair of engines, and the administration of the running department. In designing his engines, the locomotive superintendent, of course, takes his cue from the traffic department, which keeps him informed as to any projected increases of load and speed. His right-hand men are, first, an assistant locomotive superintendent, who is virtually in charge of the running department; secondly, a works manager, since most railway companies have their own engineering shops, where the locomotives are built. If a company go to private firms of locomotive builders for engines, the latter are still built strictly according to the specifications prepared by the locomotive superintendent. Below the assistant locomotive superintendent come the district locomotive superintendents, one or more locomotive accountants, and a staff of draughtsmen. This, in turn, brings us to the men who keep engines in repair at the running or steam sheds—foremen fitters, together with smiths of various descriptions; and the men and youths who prepare them for the road—coalmen, lighters-up, sand-driers, cleaners, washers-out, and bar-boys.

Chief Mechanical Engineer. As a general rule, the locomotive superintendent is no longer known by name as such, for he has blossomed forth into a far more important personage, with the title of chief mechanical engineer. In old days, the chief (civil) engineer was responsible for everything of a mechanical nature, and therefore had charge of the company's steamships, stationary engines, turntables, hydraulic installations, water-columns, etc.; whereas now it is the fashion to divide the department into two, respectively under a chief mechanical or dynamomical engineer, who deals with all moving machinery whatsoever, and a chief civil engineer, who may be said to be responsible for all machinery that does not move.

The smaller companies entrust the designing and building of carriages and waggons to their locomotive superintendent. More important companies have a distinct department for the purpose, under a carriage and waggon constructor; and the London and North-Western Railway finds it necessary to have both a carriage and waggon department, the works of the former being situated at Wolverton, and those of the latter at Earlestown, while the locomotive works are at Crewe. The carriage and waggon constructor has his own works manager, assistant superintendents, and draughtsmen, and his responsibility extends outside the works to the men who examine, repair and clean the vehicles all over the line.

Electrical Engineer. Modern conditions have added yet another highly-placed official to the engineering side of a railway in the person of a chief electrical engineer, who undertakes the maintenance of the power-houses and plant employed for traction on electrically operated sections of the line, and generating the current for lighting stations, goods yards, and offices. In addition, he advises or is intimately connected with the management of the signalling and telegraph department, as regards the rôle played by electricity in various kinds of signalling apparatus, and again, has charge of the arrangements for the lighting of passenger trains by electricity.

Signal and Telegraph Departments. The signalling and telegraph department proper is usually reckoned to fall within the scope of the chief civil engineer. Nevertheless, it possesses an organisation of its own, beginning with a signalling superintendent, and extending through a long chain of subordinates—namely, assistants, draughtsmen, signal inspectors, telegraph inspectors, fitters, signal linemen, and telegraph linemen.

Other Departments. The number of horses employed by the principal railway companies in "collection and delivery," and also (though in a steadily diminishing quantity) for shunting purposes, runs into many thousands. For example, the studs of the London and North-Western and Midland companies each include over 5,000 animals. This department is presided over by a horse superintendent, aided by an assistant superintendent, a horse buyer, and a staff of veterinary surgeons, together with inspectors of horses, provender, and stores.

The companies that own fleets of steamships and docks require the services of a marine superintendent, who exercises control over dock superintendents, ship captains, and officers, seamen, wharfingers, and dock labourers.

Now that so many companies possess hotels and also own the station refreshment-rooms, yet another department has been added to the headquarters administration—namely, that of the hotels and refreshments manager, with a staff of resident managers and cashiers.

Railway companies are empowered to let houses and lands of which they are the owners, and of which they may not require the use at the time. These circumstances call for the services of an estate and land agent, whose subordinates comprise surveyors, rating agents, assistant agents, and district agents. Lastly, for the better protection of their customers' interests and to conduce to the maintenance of good order within the precincts of stations, the companies have their own staff of police inspectors, detectives, and constables, commanded by a police superintendent or chief detective officer.

Continued

THE SUB-EDITOR

The Window-dresser of Journalism. Functions of the Sub-Editor. The Treatment of News. Headings. An Examination and Some Examples

By ARTHUR MEE

A GOOD sub-editor is worth his weight in gold, and he is as rare as he is precious. His position is second in importance only to that of his editor-in-chief. Upon him falls the responsibility of the final shaping of the paper as it goes to press. He is the window-dresser of journalism.

The Two Kinds of Papers. Most people, however little they know of journalism, know the difference between a bright paper and a dull paper. The dull paper is a sheet of solid type, in which one column looks as attractive, or as unattractive, as another; in which no effort is made to attract the eye at once to the most interesting news; in which most things are recorded faithfully and tediously as the "Annual Register" recorded them a hundred years ago. In the dull paper there is no change. It remains to-day as it was yesterday; it will be to-morrow as it is to-day. Next Saturday's copy will look to the eye very much like last Saturday's, and the date at the top is the only way we can tell at a glance whether the paper is new or old. It is the solidest and most reliable thing in the world. It never disappoints us because it gives us no expectations. It never surprises us because we know exactly what it will tell us. That is the dull paper of the old days.

The bright paper looks as though it were alive. We feel as we open it that the world is a live place and not a museum. We feel, if we read it in the quiet countryside, that we are in a dream, with all the world outside us alive with energies, and wars, and crises, and that this busy world was never so busy as this morning. We open it and know at a glance what most people are talking about. We turn to a particular place, and if our eyes meet no sensation there we know that there is no sensation for them to meet. We feel that nothing in the world is unimportant. The headings are finger-posts pointing to a hundred avenues of human interest, whereon the busy man reads all he wants to know, from which the man of leisure discovers whether the matter will interest him or not. We know at once whether we must settle down quietly to read the paper or whether a glance as we wait for the train will do. It is the genius of the modern paper that it tells us as from the housetops the things that it contains. That is the bright paper of our own times.

The Sources of "Copy." The difference between the two is the sub-editor. It is fitting here, perhaps, to consider for a moment the economy of the newspaper office. At the head, of course, is the editor, whose word is law. Below him is his assistant. It is the editor's duty to direct the general policy of the paper, but the actual machinery by which news is collected from the ends of the town and the ends of the earth is under the immediate control of the news editor, who has authority over the sub-editors. Separate from these are the reporters, responsible in London to the news editor, and in the provinces to a chief reporter. In addition to these are special members of the staff whose functions are well defined on all leading papers, but whose duties are largely covered on small papers by the general staff. Among these are the leader writers, whose duty it is to write the editorial articles which set forth the views of the paper; the musical and dramatic critics, the sporting editor, the literary editor, the financial editor, the foreign editor, the magazine editor, the political editor—all these, individually or collectively according to the position of the paper.

From all these various departments comes the supply of copy, and not from these only, but from an innumerable host of correspondents in every town in the kingdom and in every country in the world. Through the Press Association and the Central News, or, in the case of the leading papers, through local correspondents of their own, the daily papers in every town have channels of communication with every other town. From early morning till after midnight, from early morning, indeed, till early morning comes again; to-day, to-morrow, and the day after; on, and on, and on without ceasing, the stream of copy comes. It comes in scattered fragments from the ends of the earth; it meets for the first time at the sub-editor's elbow—a battle story from Havana, a Parliamentary debate at the Cape, an excavator's discovery in Babylon, a wonderful wheat crop in California, a little child's death in London—all this panorama of the doings of a world comes together on the sub-editor's table.

The Sub-editor's Qualities. It is the business of the sub-editor to prepare copy for the printer, and, simple as it sounds, the work demands the exercise of many qualities which are all too rare. His post is more difficult to fill than any other post in journalism; it may be said that a good paper is always wanting a good sub-editor.

He will have prepared himself for the sub-editor's room, perhaps, along the lines we have considered. He should possess the general knowledge essential to every journalist in any capacity, and a year or two of reporting will do him a great deal of good. The qualities that will help him most, which his work will develop in him and he should never cease to cultivate, are a capacity for discovering the most interesting aspect of events; an ingenuity of expression; a real sense of the true proportion of things; the

ability to condense a long report into a short one without sacrificing vital points; a genius for putting things in the most striking way; an excellent memory; a great contempt for verbosity or "wordiness;" and a hundred other things which only experience can reveal to him.

It is not easy to make up one's mind which of these qualities, if any, is the chief. The ideal sub-editor has all of them, and he could hardly point to any one of them and say, "I owe my success to this," "I owe my success to that." The man who will succeed as a sub-editor will do his utmost to train himself in all these varied ways. It can hardly be doubted, however, that journalism is developing along lines which make it more and more essential for sub-editors to be alert and keen not only for new facts about things, but for new aspects and new theories. It is interesting to know that a prisoner has escaped from prison, but it is much more interesting to know how he escaped. It is interesting to know that a great business has been ruined; it is much more interesting to know why.

How to Deal with News. If there has been a railway accident, it is more than likely that the most interesting thing in connection with it will be by no means the most obvious. The number of victims, though it adds to the sensation of the news, is not of any essential interest. It is terrible to know that fifty people lose their lives in a moment; it is a much more intense and dramatic thing if the accident was caused by an overworked signalman falling asleep after sitting up for a week at his little girl's deathbed. A terrible railway accident has just happened as this is being written, and one of the accounts brings out a striking picture of the train waking up the whole town as it dashed through the station and fell down an embankment. Nothing in this appalling story is more impressive to a journalist than the thought of this train waking the sleeping country town at midnight.

The sense of proportion is a vital possession. It is one of the faculties that no sub-editor can do without. He must, of course, learn to adjust it to his paper; he must, that is, realise that a proper proportion of news in one paper may be an absurd disproportion in another. Obviously, if he is on the DAILY NEWS the meetings of the Free Church Congress will be of much more importance to the readers of his paper than the meetings of the Primrose League, but the proportions would be quite reversed if he were on the MORNING POST. But he must learn a much more important thing than this. He must have the gift for discovering what is interesting to the public, and of putting these things, as a shopkeeper would say, in the front.

The Paper must Look Interesting. We come into touch here with the real genius of sub-editing. There are two supreme tests of a newspaper: Is it interesting? Does it *look* interesting? The first is the business of the editor; ultimately the responsibility for the interestingness of a paper lies with the man at the head. It is the editor-in-chief, with the news editor, who directs the supply of news which the sub-editor must deal with. Whether the matter is interesting or not is not a question for him. His concern is entirely with the treatment of it. He must, of course, decide upon the comparative interest of various items, and apportion them space accordingly, but his work lies with the matter supplied to him and not beyond it, so that in reality the question whether the paper is interesting or not depends upon the editor; he may have ideal sub-editors and his matter may still be dull.

But it is the sub-editor's own fault if his paper *looks* dull. How often are we attracted to a shop window by a bright display, only to find on a closer view that its contents do not interest us at all! The window-dresser has done his work well; he has been better than his master. The simile is so expressive that it seems hardly necessary to say any more. The sub-editor who remembers all the time that he is dressing a window will not go far astray. He must, of course, remember that even a window-dresser has responsibility. He must never deceive his readers by a heading which is misleading, any more than a draper must put superior articles in his window to advertise inferior articles inside. He must remember that in these days the busy man casts his eye rapidly over the paper, and often obtains his impression of the news of the day from the headings only.

News Without Views. More and more are headings becoming little summaries of what follows, and the sub-editor should be careful that his headings do not convey a false impression. A very striking case in point comes to mind. The proprietors of PUNCH appealed against a decision in a libel suit in which PUNCH was involved, and the appeal failed. The sub-editor was right in realising the interest of the case, but his strength was not in his discretion, and he headed the case PUNCH FAILS. It would not have been surprising to have heard a reader of that paper say to a friend at lunch that day, "I see that PUNCH is bankrupt," and one is glad, for the sake of the sub-editor and his paper, that Mr. Punch is such a merry man. The experienced sub-editor is keenly aware of the subtlety of temptation, and it is not the easiest thing in the world to write headings which shall go as far as they legitimately may go, and not a hair's breadth farther. It is not merely the risk of libel that must be guarded against, but the risk of conveying misstatements and false impressions.

Most of all the sub-editor, in writing headlines, should guard against the pernicious habit of importing opinions into headings of merely news events. It is quite legitimate for him, and may be his duty, to remember that his paper has certain views, but his first concern is not with these. In dealing with news the sub-editor should have no views; he should know no politics. He may believe that a certain man is a scoundrel, but if the man dies he must not head the news of his death DEATH OF A SCOUNDREL. Yet things are done by sub-editors quite as careless and quite as bad as that would be. Such things are not only bad journalism, but

bad policy. A newspaper is first of all a conveyer of news. It should be possible for a man of any views to buy it, to be interested in it, and to obtain from it a fair impression of what is happening in the world. The sub-editor who forgets his duty by introducing bias into news is an enemy to his paper and his profession. He alienates the very important section of the readers of his paper who do not believe in the paper's politics but who buy the paper for its news, and he encourages a practice which would make journalism the tool of propagandists and parties instead of a living history of our times.

The Wrong Sort of Headings. The sub-editor will find it all too easy to blunder in headlines. He will find himself late at night with a heap of telegrams through which he must run quickly lest they be too late for press, and he will catch sight of some word or phrase which, in his haste, he will seize upon for a heading. The result will be what often happens, that we find ourselves reading a paragraph which has no real relation to the headline which attracted us. An actual example may be more helpful than any advice.

In a London paper the other day was a report from which it appeared that a pauper in London, who was charged with assault, had been in the workhouse since he was two years old, and that in 1883 he was sentenced to penal servitude for trying to set the workhouse on fire. This paragraph was coupled with another, not to be compared with it in interest and importance, from which it seemed that a violent pauper had spoken of a workhouse as "a British Bastille." A good journalist will find it difficult to believe that an important London daily paper headed these two paragraphs ALLEGED BRITISH BASTILLE.

A Sub-editor's Sin of Omission. Let us examine the heading. It was, in the first place, bad sub-editing to couple the paragraphs. The second paragraph was unimportant, and should not have been allowed to detract from the remarkable interest of the first. But, this mistake having been made, nothing could be more ridiculous than to select the heading from the second paragraph. The result of this was that (1) the first and most interesting paragraph was overlooked, and (2) the crazy nonsense of a crazy pauper was treated with all the respect and dignity due to an expression of opinion by, say, Lord Kelvin. It is ridiculous to suggest that there is anything like a British Bastille because a pauper says so.

But it is doubtful if the sub-editor's sin of commission, serious as it was, was half so great as his sin of omission. The first paragraph was intensely interesting, and the sub-editor failed entirely to see the point in it. It is true that the report was faulty, in that it did not give the age of the pauper, which was an important fact; and the sub-editor, if there had been time, should have discovered his age. That, however, may be left out of account, for the paragraph bore inherent evidence that the man had been in the workhouse since he was two, a total of at least forty years. He was, surely, the most interesting figure in that day's papers—a man who had lived forty years without a penny of his own, who had never done a stroke of work in his life except when he tried to set on fire the home with which a philanthropic nation provided him. That is the fundamental idea of the paragraph, a human document of the greatest interest, lost to the paper through bad sub-editing.

The Inaccurate Heading. It is not possible to discuss at equal length all the other points that come up in considering headings, but we may glance briefly at a number of headings taken at random from various papers. Here is one.

LIFE ON FOURPENCE A DAY.
PAUPERS WHOSE KEEP COSTS BUT ¼D. MORE.

Nothing could be more absurd than this. The paragraph explained how certain people lived on 4¼d. a day, and the sub-editor, straining for a heading, framed one containing a misstatement and demanding an explanation. It was as if, for the sake of round figures, he had headed a war telegram

A THOUSAND KILLED IN BATTLE.
AN ENGAGEMENT COSTING ONLY 43 LIVES LESS.

Headings should never need to be explained. If they are not clear at a glance they should not be used. It is easy for a sub-editor to become so engrossed in an article that one idea stands out prominently in his mind, and to "head" the article as though it consisted only of this idea; and the result in that case might be that the heading, though fitting a special interpretation of the article, was obscure to nine readers out of ten, and possibly to the author of the article himself.

The Dangerous Heading. Here is another example of a heading which no editor should allow.

GERMANY'S ISOLATION.

"INEVITABLE" WAR WITH ENGLAND

"A PIECE OF STUPIDITY."

It cannot be doubted that the effect of this heading is to create an impression that war between England and Germany is inevitable. But we know that the sub-editor meant nothing of the kind; he meant that it is a piece of stupidity to say that war with England is inevitable. And yet the vast difference between these two meanings is allowed to rest on the mere absence of a full stop at the end of the second heading. This is unpardonable. There was, in the first place, a rule between the lines, and a rule in the middle of a sentence is absurd; and, in the second place, the mere absence of a full stop is a slight method which might be due to an accident, and in any case is quite common in headlines, and should never be relied upon in circumstances such as these. This heading conveyed to thousands of readers an impression exactly opposite to that which the paper desired to convey.

The danger of conveying wrong impressions by carelessly written headings was illustrated in another paper reporting the death of a Belfast gentleman while exploring some famous cliffs. Seizing on the word "exploring," the sub-editor

headed the report in big type EXPLORER KILLED, leading one to expect that some other Stanley or Livingstone had come to an untimely end. As a matter of fact, however, the gentleman was not an explorer at all, but a manufacturer, and all the exploring he had done was the sort of exploring we all do when we go to Hastings, or Brighton, or the Lakes, or anywhere else, for a holiday.

The Misleading Heading. An evening paper which does not often sin in this respect led its readers astray not long ago with a heading FREE POSTAGE FOR MEMBERS in its Parliamentary report. The impression conveyed—that members of Parliament were to have the privilege of free postage—was not confirmed by the subject matter; a question had merely been asked in the House. It is easier to defend this heading than some of the others we have considered, but there is a subtle error in it which sub-editors should always avoid—the error of leading people to imagine that a thing is a fact when it is merely a subject of discussion.

Another kind of heading to be watched is the joint heading which covers two things. One of the wittiest headings that has ever been written appeared in a London evening paper once when the House of Commons had an all-night sitting. It happened that at the same time the Great Wheel at Earl's Court stuck fast, its passengers being "held up" all night, and the STAR posted London that day with the words: THE HOUSE STILL SITTING; THE WHEEL STILL STICKING. There was an idea linking the two events which made excellent "copy." But the double heading is not always so happy; it was distinctly bad, for example, in a Parliamentary report concerning two separate subjects—cheaper postage for parcels and grants for necessitous schools. One question happened to follow the other in the House of Commons, and the sub-editor, coupling them, headed the report CHEAPER PARCELS AND NECESSITOUS SCHOOLS, leading the reader to wonder what subtle necessity could arise in poor schools for a specially cheap parcels post.

The Feeble Heading. The sub-editor must beware of giving undue importance to a trifling incident. The magnifying of trivial things, or the drawing of large deductions from slight incidents, is perilously near what is known in the newspaper office as "faking," an offence which puts the offender outside the pale of honourable journalism as a lie puts a man outside the pale of honourable society. "Faking" is the invention of news: a "fake" is a newspaper lie.

The sub-editor should beware, too, of such feebleness as that displayed in a paragraph quite unworthy of the paper in which it appeared not long ago. A fire, in which three persons lost their lives, occurred in London at Easter, and the inquest took place on Wednesday of Easter week. Following the report in a morning paper was a paragraph with a heading REMARKABLE COINCIDENCE; a paragraph with no other substance than the fact that on Wednesday of Easter week in the previous year also an inquiry was held in London into the deaths of three persons as the result of a fire. Nothing could well be feebler when we remember that lives are lost by fires in London almost every week; that Easter week could hardly ever pass without such an event; and to speak of such a commonplace as a remarkable coincidence is only to deprive oneself of the power of description when something really remarkable does happen.

The Legitimate Heading. But the candidate for sub-editing will study the papers for himself, will re-write headings as often as he can, and will learn the art of making them short, direct, and comprehensive. There is, of course, a display of headings that is perfectly legitimate, and, indeed, desirable. The days of the old journalism are dead, and the papers which cling to its traditions are dying. They are not, at any rate, the papers of the future. The interesting and enterprising papers of to-day are so familiar to us all that there is no need to single them out, and the journalist can study them as often and as much as he likes. He can compare the papers with old-fashioned headings, which still give a column of interesting matter under one uninteresting headline, with the papers which make their articles attractive; and he can choose which he likes best.

He has only one choice, however, if he is to make his way as a sub-editor. There was admirable wit and meaning in a conversation the writer overheard in a restaurant in London. Two men were discussing newspapers. One thought the TIMES uninteresting. There were no headings to guide him, and so on. "The end of the world might come," he said, "and if you took in only the TIMES you would never know it." It is the business of the newspaper to *tell* its reader what has happened, not to compel him to search for the news with a microscope, and the newspaper which puts away the announcement of the end of the world in a corner will abundantly deserve its doom!

The American Heading. It is not, of course, desirable to follow the example of the American sub-editors, whose papers are made intolerable to English journalists by columns of headings which are a disgrace to the King's English. BRIDGE JAM WORST EVER was one of these; it was the sub-editor's way of saying "The Worst Bridge Accident on Record." But the line between the extremes is not difficult to draw, and the instinct of the true journalist will lead him aright.

We may sum up all that is to be said about headings, perhaps, in one or two words. If we have to choose as sub-editors between making a dull article look interesting, or making an interesting article look dull, we must make the dull article look interesting. The days when people read everything have gone, and every reader has become an editor. Every person who reads a paper edits it for himself. He will read only what appeals to him, and *only what appeals to him at once*. He will not sit down to make up his mind whether to read an article or not. He makes up his mind at once when he sees the

heading, and the paper which is full of good matter with bad headings will not be read.

The Ideal Heading. The ideal heading is interpretative as well as descriptive. It is an idea rather than a phrase, or, better still, it is both. It strikes the mind at once. It does not call for any mental searching, or for dictionaries. It is plain to the man who runs. It is never misleading, but it need not be severely narrow. It need not be without imagination. It is suggestive, and may express with freedom not only the facts in the article but the thought behind it. It is written in the language of the people, and not in narrow terms of science, or theology, or great learning. It is wide, and free, and clear, yet definite and not vague, accurate and not ambiguous. It puts a thing in the way in which it will appeal to the largest number of people among those for whom it is written. The hope in the journalist's mind when he writes it is that it may impress itself so vividly upon the minds of those who read it that they will not casually pass it by. It takes the line, not of least resistance, but of widest acceptance.

The heading of articles does not, of course, by any means comprise the whole of the sub-editor's work, but it is probably the most important side of it. We have, moreover, devoted special consideration to the subject because a full understanding of it implies a general capacity for sub-editorial work, and in treating of headings we have been able to consider incidentally many aspects of sub-editing.

Kinds of Headings

The sub-editor should make himself familiar with all kinds and sizes of types, and with all forms of headings. There are many kinds of headings. The main title of an article is called the *heading;* the remaining titles are *sub*-headings. The heading of this paragraph is a *side*-head, standing above the matter either to the left or right of the column. The ordinary paragraph headings in the SELF-EDUCATOR are *run-on side*-heads, forming part of the first line of the paragraph. The heading of the next paragraph is a *cross*-head, standing above the matter in the centre. The other specimen shown is a *cut-in side*-head, let into the paragraph in a square space two or three lines deep. The general page headings to articles in the EDUCATOR are known as *box*-headings, a border being placed round the type.

THIS IS A CROSS-HEAD

Such headings have two objects; they may be either finger-posts to the article or simply means of display intended to relieve the solid appearance of the article. A simple way of relieving the heavy appearance of solid type, often adopted in speeches, or stories, or descriptive sketches, is to mark a number of pointed phrases at convenient distances for the printer to set as small cross-heads. This may be done quite easily in the manner indicated at the end of this paragraph, and if the last words of a paragraph are suitable for a heading it is much more convenient for the printers if these are selected. A smart sub-editor can very quickly give a solid column of matter an interesting appearance by making half a dozen [marks of this kind.]

This is a Cut-in Side-head Leaded type is type with blank spaces of varying thickness between the lines, thus making it more easy to read, and it is usual to "lead" articles of special importance in order to call attention to them. The leading articles in most newspapers are leaded. The size of type is governed by the relative importance of matter, and stock features occupying considerable space, such as commercial and sporting news, are usually set in smaller type than the rest of the paper. Small type is, as a rule, to be deprecated, and the type in which the EDUCATOR is set, known as bourgeois, is the usual size for magazine reading.

Office Books. In dealing with the copy that comes before him the sub-editor should bear in mind all that has been said in this course and all that is to be said. Only experience can teach him the various ways of dealing with copy; the cutting down of an article five times as long as it should be; the elaborating of an expensive cable which has more points than words, or the dealing with a telegram which has, unfortunately, more words than points; the re-writing of an important piece of copy written without regard to order or grammar or proportion; the elucidating of obscure points; the introduction of explanatory notes and comments. He will know all the reference books which the journalist must have at his elbow; will know every page of WHITAKER and HAZEL: will be familiar with HAYDN'S DICTIONARY OF DATES, with the most up-to-date encyclopædia—at present the HARMSWORTH ENCYCLOPÆDIA; the index to the TIMES, and, of course, the inevitable and indispensable WHO'S WHO. Most of these and a score of other reference books are on the shelves of every well-equipped newspaper office. The sub-editor will have available, besides, the cabinet of information which every efficient newspaper maintains on lines we shall consider later.

He will find his work trying, involving an early beginning if on an evening paper, or working until the early hours of the morning for a daily paper; and unless he is strong and able to concentrate intensely for a long period he should not become a sub-editor. If all the conditions are favourable, however, he will find his work interesting, and if he does it well he may be certain of appreciation and advancement. A good sub-editor is assured of a comfortable living as long as papers last.

Continued

WORK IN THE BOOT FACTORY

Bootmaking Machinery and its Operation. Sewing, Eyeleting, Skiving, and Sole-cutting and Pressing Machines

BOOTS AND SHOES continued from page 4140

By W. S. MURPHY

FOR fifty years after machinery had been used for making boots the man who entered the trade had to count on meeting a hostile public opinion, in Great Britain especially. During that period it would have been as dangerous to offer an English gentleman a pair of machine-made boots as to suggest that he ought to wear a nose-ring. We say that the hostility was one of opinion, not prejudice, for it was founded on experience and fact. Machine-made boots were either very ugly or very unreliable, and sometimes they were both.

The First Machine-made Boots. The reasons or excuses for this state of matters may be put under two heads—namely, the low-class market catered for, and the crudities of the machinery. The factory trade was always a shop trade, and well-to-do customers seldom patronised the shops, or, if they did, it was the bespoke department. Cut-throat competition had reduced profits on factory-made boots to almost nothing, and in the effort to cheapen production, manufacturers introduced machinery. To attempt the market in which the well-to-do purchased seemed hopeless; the way to success was production of boots at popular prices in attractive styles. Cheapness, for the time, became the sole aim of the machine boot manufacturer, and when cheapness is the chief objective, quality suffers. During the seventies of the nineteenth century, the British boot markets were flooded with a class of boots unworthy of the bootmaking trade; no worse were ever made since boots were worn; but they were low in price. People, however, soon found that the low-priced machine-made boots were not cheap, and a strong reaction set in. Everybody who could afford it went in for hand-made boots. A considerable section of the artisan class remained who were unable to buy hand-made boots, and for this market the boot factories competed. Prices were maintained, but quality was improved. To meet these circumstances, manufacturers demanded and got better and more reliable machines, or paid the high prices machine makers had required for the best machines.

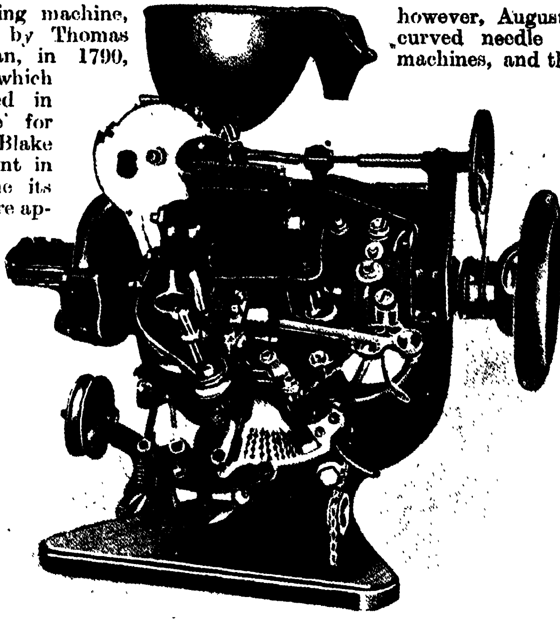
Bootmaking Machinery. According to American authorities, the idea of making boots by machinery originated from an invention by David Meade Randolph, in 1809. The boot in which the sole and uppers are united by pegging has always been made somewhere or other. Randolph's machine was devised to insert the pegs and clinch them on an iron last. In 1810, M. I. Brunel, improved on Randolph's idea, and patented a sole-riveting machine, which produced fairly good work of its kind.

Sewing Machine. During the following 40 years the pegging-machines were improved, but the main direction of inventive effort was towards the making of a machine that would

35. SEWING ON THE SOLE BY A BLAKE OR McKAY CHAIN-STITCH MACHINE

36. CUTTING THE PATTERN TO THE LAST

sew soles. The sewing machine, originally invented by Thomas Saint, an Englishman, in 1790, gave the idea upon which Lyman Blake worked in devising a machine for stitching on soles. Blake brought out his patent in 1858, and for a time its imperfections were more appreciated than its merits; but the Civil War gave Blake his opportunity. Boots were needed in a hurry for the armies the Northern States were massing to fight the Confederates, and though not perfect, Blake's machine [35] could produce sewn boots with great rapidity. The original machine is thus described: "This machine is a chain-stitch sewing machine. The hooked needle works through a rest or supporting surface of the upper part of a long curved arm, which projects upwards from the table of the machine. This arm should be of such a form as to carry the rest into the toe. . . . There is a looper in the rest, or horn, and this looper lies in the path of the needle with an eye. The thread is led along the curved arm up through the looper and into the eye of the needle, tensions being on it."

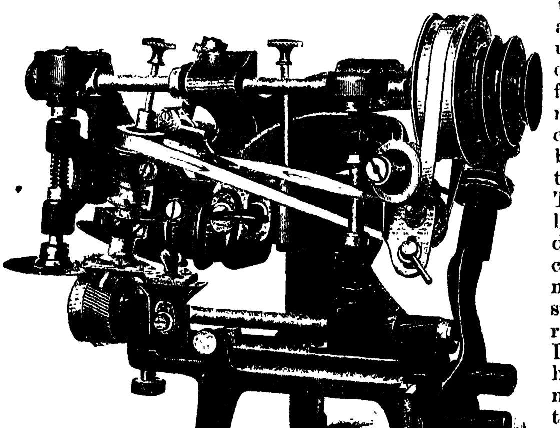


37. DUPLEX EYELETER (B. U. Shoe Machine Co., Leicester)

Though this first Blake machine professed to take the thread into the toe of the boot, it was not quite successful, and in 1860 an improvement was added which obviated that defect.

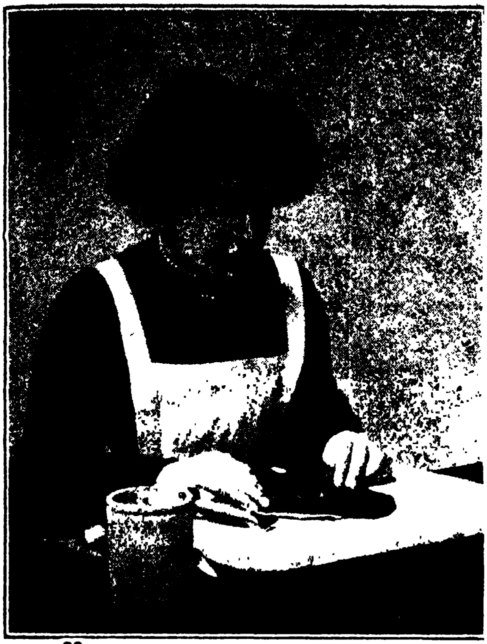
Improved Sewing Machine. As the sewing machine then stood, it could not be accepted as a substitute for the hand sewer. It was rather a substitute for the pegging machine. In 1862, however, August Destory invented a curved needle for use in sewing machines, and the American partnership, Goodyear and McKay, successors to the Blake firm, took hold of the idea, and brought out a machine which could sew the boot on the last, and imitate hand sewing.

British Machines. That is the story of bootmaking machinery on the other side of the Atlantic; but its history on the British side is somewhat different. Long before machinery for boot-making was thought of in America, a Leicester firm had devised machinery for the purpose, but the inventions were laid aside. With plenty of skilled labour at hand, the need for machinery was not keen. Besides, the boot required for the British climate did not lend itself readily to machine manufacture. For the American climate, boots lightly pegged and slimly sewn were the very thing, and for this class of boot the machines were adapted and speeded up. Here we have an explanation of the failure of bootmaking machinery in this country when it was brought over from the United States. The American style of boot was not introduced, but the machines were used for making ordinary strong boots, and the results were pitiable. In a very short time, however, the machine manufacturers rose to the occasion, and invented machines suited to British needs.



38. FRICTION-FEED AMAZEEN SKIVING MACHINE (B. U. Shoe Machine Co., Leicester)

Progress. Year by year mechanical skill has overcome more and more all



39. FITTING TOGETHER THE UPPER

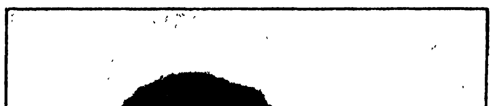
the problems of bootmaking, till, at the present day, a well-equipped factory can produce boots that will stand comparison with the ordinary products of the craftsman. It is true, there will always remain a large field for the hand-made boot, and no one who loves his craft would wish it otherwise. No matter how excellent the machine, it can never equal the skilled hand in special lines; the highest class of boot is the special work of a special man. But for the great boot market of the world, the public willing to wear boots short of perfect, at a fair price, the boot factory is the great source of supply.

Number of Operations. As it stands at present, the boot factory is a fine example of the division-of-labour principle in practice. For every detail there is a machine. The making of a boot-top, for example, is a straightforward matter, but our machinist has broken up that process into no fewer than 16 different parts, each part with a machine specially designed to perform that one act alone. Let us take an instance. By smart work a bootmaker can eyelet a boot in about a minute, but here is a little machine that eyelets boots at the rate of 100 a minute [37]. The saving of time is simply enormous. All round the factory the same thing happens. By putting a machine, or set of machines, to carry through one simple detail, you increase production and lessen cost.

The Two Departments. The boot factory, like the bootmaking trade, is divided into two large divisions—the upper-making and the bottoming departments. There are even factories which do nothing except make tops; but, curiously enough, there are no factories employed exclusively in the soling and heeling business, and the question is, Where do all those boot-tops go? We fear that a good many bootmakers buy machine-made tops for hand-made boots. This is no trade secret, but a fact generally accepted, though it may not be widely known among the boot-buying public. Bootmaking by machinery is a succession of small details which may confuse unless we have a clear conception of the general plan of the factory. Before undertaking any piece of work, therefore, we will go round the factory, look into its arrangement, and view the process of manufacture as a whole.

The "Upper" Department. The first division of this department is the cutting or clicking room. The pattern is first cut in paper to the last [36]. Here boot-tops are being cut by the hundred. If the factory be of moderate size, one man is employed on each part of the top; in very big factories groups of men act in the same way, one group cutting out fronts, another group backs, another quarters, and so on. At the same time a smaller section of workers are busy cutting out linings, bindings, and such things. Observe the system. A well-organised boot factory is arranged in a series of circles. From the store-room counter at this side the leathers and cloths are given out, and the materials seem to circle round the cutting-room, and return in the shape of the various parts of boot-tops. Having been inspected, the materials are passed into the machine-room.

Machinery. The machine-room is a place of pretty machines, some of them small enough to go into a man's coat pocket. Here the circular motion is observed. First the parts of the uppers are skived—that is, reduced in substance at the edges. This may also be performed by machinery [38]. After this and other preparation



40. FITTING THE VAMP ON A BLOCK

41. CLOSING UPPERS IN A FACTORY

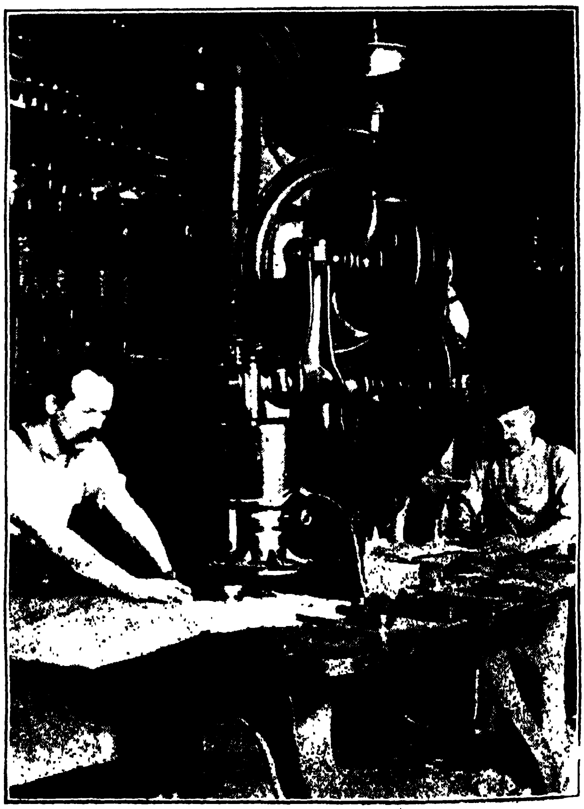
rounding machines [43], each of which consists of a travelling knife made to travel round a wooden pattern the size and shape of the insole or outsole as the case may be. The heavy rollers are for compressing the leather, and take the place of the lapstone of the older craft. Guillotines for cutting the hides or butts into strips are also to be found in this department. Machines for levelling [46] the lumpy parts off the leather are also placed in here. Sole moulders [44] are used for blocking the bottom stuff to the curvature of the lasts, so that when they are sewn they shall be in their proper position. The counters or stiffeners are skived and moulded to shape by the counter moulders [45], while the insole machines feather or bevel the edges so that the substance of the leather shall not hurt the foot or cut into the upper.

The other range of machines last the uppers to the bottoms, tack the soles into position, lay the soles flatly to the shape of the

the parts are fitted or pasted together [39] to keep them in position while machining. Sometimes this is done to a shape like a last [40] so as to give it a better shape and fit. Linings and tops start on opposite sides of a row of machines, and move along from hand to hand, receiving additions and joinings at each machine, and then they meet, to be put together. In this shape the tops complete the circle [41], arriving at the other end as boot-tops ready for the bootmakers.

Inspection. Before the tops go down to the makers they are passed through the inspecting-room. This is a very important department in all machine factories. With a machine driven at 1,000 revolutions a minute the worker has not time to stop and repair slips; with the inexorable supply coming in on one side of her, and the continuous demand from the machinist on the other side, there is nothing for it but to go ahead. As a natural consequence, a small percentage of defective work is passed through, and must be checked.

The Bottoming Department. Heavy machines are used in this department, and it is therefore planted, where possible, on the ground floor. The machines are grouped together in two divisions, those used for preparing the bottoms, such as presses [42], which are used to press or cut out the sole leather into shapes corresponding with the shape of the bottom of the last; sole-



42. CUTTING SOLES UNDER A DOUBLE OPEN-ENDED PRESS

last, and sew the soles to the insoles, rub down the channels and relay the soles, build the heels, and perform many other similar processes. As we watch the process, we cannot help reflecting on the figure it presents of human social development, each generation taking the achievements of its predecessor, adding its quota, and passing the work forward. Beside each machine is a pile of stuff, and as the lasted tops come round another piece is added on, and sewn in place, and the boot is passed forward to another worker, who also adds something.


44. MOULDING THE SOLE TO THE SHAPE OF THE LAST

Finishing - room. From the making-up division the boots are taken into the finishing-room. Here there are machines that turn the heels into their required shape, revolving scouring-pads for giving them the requisite smoothness, and burnishers for imparting the high polish so much admired. The edges of the sole are trimmed to shape by the edge-trimmer, and set by an oscillating heated iron to prevent easy access of water or damp. The bottoms are scoured and stained and polished — all working swiftly on the boots and changing them from rather rough-looking things into finely-finished footwear.

In following the boots we have unconsciously come out of the region of machinery into the quiet of officedom again, and here the inspectors are silently going over the boots before the packers take them away. A peg has sprung, a welt has broken, the channelling has frayed —any damage, small or great, is instantly detected, and the boot thrown out. As the boots are passed, the packers take them away, and they go to the market, wherever that may be.

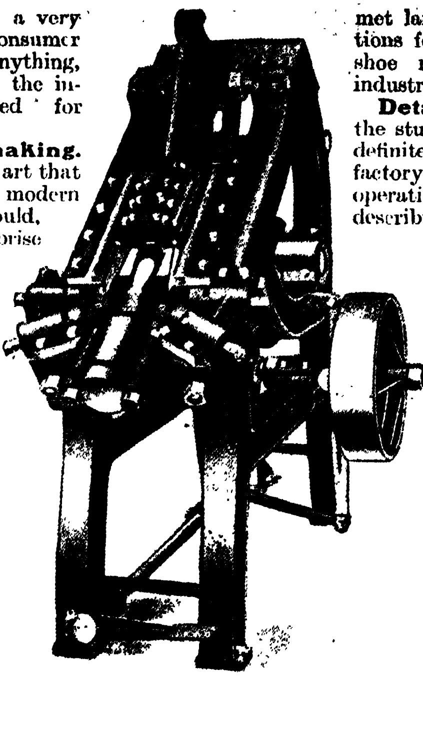

43. SOLE-ROUNDING MACHINE

Various Factories. From this sketch a general notion of the boot factory may be gathered; but it hardly gives a full account of the trade. Some particulars must be added. Boot manufacture offers a wide and varied field to the industrious and persevering worker. Factories have been established for the making of one class of boots only. One factory that we know very well is employed in producing ladies' fine boots, and that variety alone; another makes children's and youths' chiefly; and there are other works in which only heavy boots are made. This specialisation, while it tends to restrict the worker's experience, affords opportunities to the young and enterprising man seeking to start in business. Matters have come to such a pass that the operative must surrender all hope of acquiring a knowledge of his whole trade in the factory. There is no injury, therefore, in the limit put upon his acquirement by the specialisation of the trade. It is to meet the need thus created that this work has been written. By technical study alone can the worker hope to rise above the position of a machine-minder, or detail labourer, and regain his status as a skilled craftsman on the higher plane offered by machine industry.

The modern development of the factory system has tended to cheapen and improve the footwear of the medium quality grade. The excellency of the machinery used has given for the same value expended in shoes a better built article, and although the price of the raw

material has increased to a very large percentage, the consumer has had to pay little, if anything, extra for this owing to the increased facilities adopted for production.

Science in Bootmaking. The amount of science and art that can be, and is, applied in modern shoe manufacturing would, upon investigation, surprise those who think there is nothing much in shoemaking but practical experience and skill. The lasts are copied from models by a scientifically-constructed lathe with a proportional attachment like a pentograph to regulate the lengths and widths; the patterns are cut and scaled into sets by geometrical means with mathematical accuracy; the variations caused by the various substances of leather are calculated and applied by scientific methods; the skins are laid out to get the best economical results combined with a correct disposition of the material so as to produce boots and shoes that will endure the strain brought to bear upon them during wear; and all through the various departments of the factory we find scientific methods in vogue in place of the empirical methods of the older craftsmen.



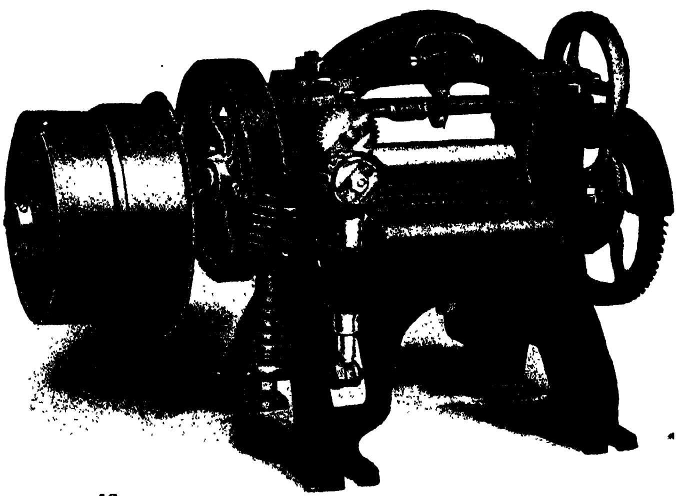
45. STIFFENER MOULDING MACHINE
(B. U. Shoe Machine Co., Leicester)

The finishes and colourings of the bottoms are art productions, and much thought and skill are brought into play in this section.

Treeing and dressing of the upper has become quite an important branch, and a vast amount of knowledge is displayed in selecting the materials and methods of dressing so as to avoid anything likely to ruin or spoil the durability of the leather. This demand upon the worker has been met largely by the technical institutions formed in all the centres where shoe manufacturing is the staple industry.

Detailed Study. In order that the student may possess a clear and definite knowledge of the whole boot factory, we purpose going into all the operations in detail, illustrating and describing the principal machines used. We shall stand by the side of the "clicker," and learn how to cut out the tops from the thousands of patterns kept in the factory. By a series of tables compiled from wide experience we exhibit the scientific methods of measurements by which the machine bootmaker has been able to meet the requirements of customers of all ages, classes, and tastes. Following the "stuff" of the boot-top, we examine the various sewing machines, and machines of various application, noting the special action and function of each, till the completed top has been realised.

Next comes the bottoming department. Here we begin with the cutting machines, striking out with dies soles and insoles, splitting welts, and shaping the various parts of the materials. Lasting is an important operation, and the appliances must be carefully gone over. Welting, cementing, and sole-laying are the next operations, and then follows sewing. The Blake sewing machine [35] has already been noted, but the practical working of it is further to be explained. Sole-pegging is another ingenious operation, and we find out the reasons why pegging has been restored to public favour after a long period of unpopularity. The heel then claims careful and detailed attention.



46. SOLE-EVENER (B. Shoe Machine Co., Leicester)

Continued

THE MYSTERY OF MAGNETISM

The Magnetic Needle. The Mariner's Compass. Magnetism of Metals. Magnetic Sounds. Magnetic Belts. The Error of the Compass

Continued from page 4094

By Dr. C. W. SALEEBY

WE must now turn to a systematic if brief discussion of a subject to which reference has frequently been made in preceding pages. We had no choice but to consider the relations of light, magnetism, and the electromagnetic theory of light before we had properly defined certain of the terms which we employed. But, at any rate, these references to the subject must have interested the reader in it. It is the old story: *electricity*—which derives its name merely from the Greek word for amber—was once a sort of freak phenomenon, but now its study dominates the whole of the natural sciences; and, similarly, *magnetism* is derived from the Greek name for a particular ore of iron, but is now recognised to be a phenomenon of the widest possible practical and theoretical interest.

The ancients knew that the *lodestone*, or *magnetic iron ore*—which, as the reader may remember, has the formula Fe_3O_4—is capable of attracting iron, in whatever form, and of endowing such iron with a measure of its own properties. They also knew that other metals do not share in this property, and that the intervention of other metals between the magnet and the iron does not interfere with the attraction. But to the few facts they knew they added a vast amount of pure fiction, which was accepted as fact for many centuries.

Invention of the Compass. According to Professor Chrystal, it was the invention of the compass that marked the first epoch in the science of magnetism. It is commonly believed that to the Chinese must be ascribed the first invention of this wonderful little instrument. It is stated by the Chinese historians that in the twenty-seventh century before Christ the compass was used in war. It is also a Chinese dictionary that first defines the lodestone. The Chinese appear to have long used the compass upon land before it was employed in navigation. It seems quite possible that the Chinese communicated their knowledge to the Arabs, and that the Arabs introduced it into Europe. At any rate, even in the twelfth century European sailors employed a primitive form of compass which "seems to have consisted simply of an iron needle which was touched with the lodestone and placed upon a pivot or floated on water, so that it could turn more or less freely. It was found that such a needle came to rest in a position pointing approximately north and south. . . . As these compasses were made of iron (steel was not used till much later), and were probably ill-pivoted, they must have been very inaccurate; and the difficulty of using them must have been much increased by the want of a card, which was a later addition, made apparently by the Dutch."

Discoverer of the Earth's Magnetism. The next stage in the history of our knowledge of magnetism is undoubtedly represented by the life-work of Dr. William Gilbert, of Colchester, who was physician to Queen Elizabeth, but who will be remembered not as a physician, but as "the Galileo of magnetism." It is true that he was President of the Royal College of Physicians and achieved great professional success, but he added nothing to medical science. On the other hand, he published, in the year 1600, the greatest work that has ever been written upon magnetism. He died three years later at the (probable) age of 63. Gilbert was the absolute pioneer in this subject. Not only did he make many experiments, but we owe also to him the capital discovery of the magnetism of the earth. Having found that the whole earth is none other than a great magnet, Gilbert was thereby enabled to explain not only the direction occupied by the compass needle, but also what is known as the *magnetic dip*. Says Fuller, in his "Worthies of England": "Mahomet's tomb at Mecca is said strangely to hang up attracted by some invisible lodestone; but the memory of this doctor will never fall to the ground, which his incomparable book, 'De Magnete,' will support to eternity."

Two or three years ago Professor Silvanus P. Thompson delivered at the Royal Institution some most interesting lectures upon the work of Gilbert, the tercentenary of whose death fell in 1903. Professor Thompson claimed for this remarkable man even more than is generally acceded to him, and supported the claim by many quotations. It amounts to this—that Gilbert must be regarded as a forerunner of Bacon himself in his exposition and demonstration of the true method of science—the method of induction—the interpretation rather than the anticipation of Nature. Certain it is that not only did Gilbert practise the scientific method, but he did so consciously, having a formal comprehension of its principles and of the need for it.

The Axis of a Magnet. We are apt to think of a magnet as a thing with two ends, but it is well to follow the example of Gilbert himself and take the case of a spherical magnet, which also has "poles." The phenomena of magnetism do not at all depend upon the form of the magnet. We shall afterwards see that they are not *molar*, but *molecular*. Such a spherical magnet, then, like any other, has an axis and poles. That end of the axis which always turns northwards we usually know as the north pole, and conversely. We shall soon see that it would be much more correct to describe the northward-turning pole of the magnet as its south pole and the southward-turning pole as its north pole. At any rate, when the magnet

comes to rest, the vertical plane in which its axis lies is known as the *magnetic meridian*, indicating respectively the magnetic north and the magnetic south.

The Magnetic Needle. Having disposed of the notion that the molar form of a body has anything to do with its magnetism, we may now study the more common form of artificial magnet, usually called the *magnetic needle*. This will consist of a thin piece of hard-tempered steel which has been magnetised in one way or another. It may have been rubbed with a piece of lodestone or with an artificial magnet, or it may have been made magnetic by electrical means. A steel knitting-needle can easily be magnetised by the first process. First of all we must have some means of distinguishing one end from the other. Let us decide that the end we shall call A is to become the north pole of the magnet and the other end, B, the south pole. Let us then take a magnet, place its north pole on the point A of the knitting-needle, and draw it along the needle from A to B. Similarly, we may draw the south pole of the magnet along the needle from B to A. If this process be repeated often enough, we shall find that the knitting-needle has become magnetic. Such a magnetic needle may be made to float upon the surface of water, not because it is magnetic, but because of the surface tension of the water, as the reader will doubtless remember. And we find when we lower it very gently upon the surface of water that it will slowly turn until it comes to lie in the magnetic meridian. It is of the utmost value in many experiments to have a needle thus balanced so that it can move freely in a horizontal plane. A method employed by Gilbert, besides the method we have just described, was to suspend a very fine magnetic needle from a single fibre of silk, which scarcely interfered at all with its movements.

The Magnet and the Poles. What is known as the magnetic dip was independently discovered by several observers before the time of Gilbert. In 1544, a German vicar discovered that the magnetic needle, as he says, points downwards. "This may be proved as follows. I make a needle a finger long which stands horizontally on a pointed pivot so that it nowhere inclines towards the earth, but stands horizontal on both sides. But as soon as I stroke one of the ends with the lodestone, it matters not which end it be, then the needle no longer stands horizontal, but points downwards."

The magnetic dip varies in different places. It does not exist at all along a line which corresponds more or less with, but along a line which definitely differs from, the equator of the earth; this line is known as the *magnetic equator*. North of it the north end of the needle dips below the horizon; south of it the south end dips below the horizon. In each hemisphere, north and south, there is a point where one end or other of the needle dips vertically downwards. These points are known as the *north* and *south* magnetic poles of the earth respectively; but a further study of them belongs to the subject of terrestrial magnetism, and here we are dealing with the whole subject historically.

The magnetic dip having been discovered just before the time of Gilbert, it remained for him to explain it in terms of terrestrial magnetism. Before him there had been made, but not explicitly stated, the notable discovery of the mutual behaviour of the poles of magnets. This behaviour may be expressed by the very simple rule that *like magnetic poles repel, unlike magnetic poles attract each other*. The law of the intensity of this magnetic attraction and repulsion is the law with which we are already so familiar—it varies inversely as the square of the distance.

The Elements and Magnetism. As the name of the whole subject implies, there are inherent differences between the elements in respect of their magnetic properties, and this is a subject of which the chief student, beyond a question, is Michael Faraday. The pre-eminently magnetic substance is iron; with this, of course, we may include steel, since, as the reader remembers, iron is its chief constituent. Long after this element we must place nickel and cobalt, and also manganese and chromium. Faraday studied an enormous number of bodies, and divided them into two great groups. Those which behave like iron, being attracted by magnets, he calls *para-magnetic*, while those which are repelled in greater or less degree by magnets he calls *dia-magnetic*. We need not give the list of substances which he tested. The interesting fact to notice is that almost every kind, if not absolutely every kind, of substance that can be experimented with is acted upon by a sufficiently powerful magnet in one way or another. We may select the following substances from Faraday's list of dia-magnetic bodies in order to show their heterogeneous character: Rock crystal, nitrate of lead, citric acid, water, alcohol, nitric acid, alkaline salts, glass, iodine, resin, sealing-wax, jet, sugar, wood, leather, beef, and blood.

The Magnetism of Metals. Of special interest is Faraday's study of the relative magnetic properties of the different metals. This must be of even greater interest to us than to him, for we are much nearer than he towards finding the clue to the facts. The following is Faraday's list of metals in order of descending susceptibility to magnetism reading down the columns. It requires a certain amount of revision, due, for instance, to the probability that iron is found as an impurity in several para-magnetic metals named:

PARA-MAGNETIC

Iron	Manganese	Cerium	Palladium
Nickel	Chromium	Titanium	Platinum
Cobalt			Osmium

DIA-MAGNETIC

Bismuth	Cadmium	Silver	Uranium
Antimony	Sodium	Copper	Rhodium
Zinc	Mercury	Gold	Iridium
Tin	Lead	Arsenic	Tungsten

The Range of Magnetism. But we must realise further that magnetic properties are by no means confined to solids. For Faraday

found that gases have magnetic properties, though it is not necessary here to quote the table of his results. The most magnetic of all gases is apparently oxygen, though it may possibly be surpassed in this respect by its own modification, ozone.

Within the limits of magnetic action, the interposition of material bodies is of no more moment as such than it is in the case of gravitation, provided that the intervening bodies be themselves non-magnetic. It has already been noted that this important fact was recognised some centuries ago.

Though various forms of iron, for instance, are capable of magnetisation, they vary very much, and at present very mysteriously, in their behaviour when so magnetised. A piece of soft iron will become a magnet when it is touched by or placed sufficiently near to another magnet; but so soon as it is removed from this influence, its magnetic powers vanish. Steel, however, or a hard enough iron, when adequately magnetised, will retain the property indefinitely. We are as yet quite incapable of explaining these differences. No wonder, the thoughtful reader will say, when he remembers that we are hitherto incapable of reducing to their ultimate basis the properties of hardness and softness. This is certainly not a chemical question of the admixture of carbon or other elements with the iron, but somehow depends upon the physical constitution of the bodies in question.

How Physical Conditions Affect Magnetism. Certain illustrations of the effect of physical conditions upon magnetism may be quoted. Thus, in the case of soft annealed iron, under certain conditions a considerable percentage of induced magnetism can be retained. But the mere effect of a tap is sufficient to destroy this. This single instance is extremely suggestive.

Then, again, we may take the influence of temperature, which is found to be very decided. Up to a certain point a rise in temperature in the case of soft iron greatly increases its response to magnetism. Yet a point is reached beyond which the reverse action occurs, and the magnetism of the iron disappears. It is indeed true for all specimens and all varieties of iron or steel that there is a temperature—varying, of course, in different cases—which we may call the *critical* temperature, and beyond which the magnetism entirely disappears.

We commonly think of a magnetic needle as having two ends, which we distinguish as its north and south poles; but this is only a relation, and the remarkable fact which we discover when we break up such a needle is that this relation holds good of all its parts. Break the needle in two and each half becomes a magnet with its own north and south pole, their positions corresponding to those of the unbroken needle. Break up these halves again and the same result is found. Must we not then conclude that the ultimate molecular units—not, of course, the ultimate units—of such a magnet are themselves magnetised? In short, must we not form some *molecular theory of magnetism?*

A Limit to Magnetism. In the attempt to form such a theory we may note various facts, some of which have already been referred to. For instance, we may note the parallel statements of Wiedemann, which show us the apparent parallelism between magnetism and other physical conditions, for the explanation of which we must refer ourselves to the molecule. Thus:

1. Jarring a body under twisting stress causes increase of twist.	1. Jarring a bar under magnetising force causes increase of magnetisation.
2. Permanent twist in a wire is diminished by jarring.	2. Permanent magnetisation in a bar is diminished by jarring.
3. A wire permanently twisted and then partly untwisted loses or gains twist when jarred according as the untwisting is small or great.	3. A bar permanently magnetised and then partly demagnetised, loses or gains magnetisation according as the demagnetisation is small or great.

We owe to Weber the original form of the theory which attempts to explain such facts as the above in molecular terms. We may call it the theory of molecular magnets—the theory that the individual molecules of iron or steel are themselves magnets. Weber supposed that in unmagnetised iron the molecules are lying in all directions indifferently, and that they, therefore, neutralise each other's action, with the result that the mass as a whole has no magnetic action. Then, when the iron is magnetised we may suppose that the molecules have all been turned more or less in one direction, so that their action is summated instead of being mutually neutralised. Such a theory evidently leads to the conclusion, which is verified, that there is a definite limit to the possible magnetisation of any body.

In some form or other Weber's theory must probably stand. It has been somewhat modified by the suggestion that the molecules are not independent of each other but grouped in certain positions; and this supposition may serve to explain more of the facts.

Magnetic Sounds and Magnetic Belts. Under certain conditions sounds may be produced by the magnetisation and demagnetisation of iron and steel, the production of the aerial vibrations being due, doubtless, to mechanical changes in the metals. It was the great Joule, to whom we have often referred, who first clearly recognised that "the magnetic extension in the core of an electromagnet takes place so suddenly that the shock is sensible to the touch, and is accompanied by a musical note arising from vibration in the metal." The earliest telephone on record depended, according to Professor Chrystal, essentially on the magnetic sounds produced by a varying current in an iron core.

No doubt there may be magnetic belts on the market which do contain magnetised portions of steel or iron, though in many cases it is impossible to discover any activity in these articles. Statements designed to indicate the potency of the magnetism, and asserting that

it will act through various non-magnetic obstacles, will be appraised at their due worth by the reader. The potencies and properties of magnetism and its relations to the living body are, of course, obscure, though certain definite facts are known, as we shall see. But it may be most positively stated that there is no evidence whatever to show that these magnetic belts have any appreciable action of any kind upon the body. That good results may sometimes follow their use proves nothing whatever as to their possession of any definite physical properties. For, as in a thousand other instances, the great majority of diseases are famously affected by anything in which the patient can be induced to believe. The interest of magnetic belts, therefore, is not really physical but psychological, and comes under the heading of the subject which the psychologist calls *suggestion*.

The Earth, the Sun, and the Magnetic Needle. In our brief introductory history of this subject we have already outlined one or two of the facts of terrestrial magnetism. We have seen that William Gilbert explained the behaviour of the magnetic needle by the extremely bold but justified speculation that the earth itself is a huge spherical magnet. It was this theory which led Gilbert to experiment with little spherical models of the earth which he called terrellæ, or *little earths*. We have also noticed the existence of the magnetic poles of the earth, and may briefly note that the term *isoclinic lines* describes lines drawn on charts of the earth so as to pass through places where the angle of dip is the same. At the magnetic poles the angle, of course, is 90 degrees. Again, though we speak of the needle pointing north and south we must remember that, except along two lines, there is a *declination*, or variation, at every point upon the earth's surface between the true meridian and the magnetic meridian. "Isogonic lines" indicate places where the declination is the same.

Poets are apt to use the magnetic needle as a symbol of constancy—"true as the needle to the Pole." But, as a matter of fact, there are incessant changes in the behaviour of the needle at any given place as regards both *variation* and *dip*. Some of these can scarcely be measured in less than centuries, others definitely correspond to the year, and others, again, may be measured from hour to hour. Lastly, we may note the amazing fact that the behaviour of magnetic needles on the earth is influenced by the state of the sun. It is definitely known that sun spots affect the magnetic needle.

The Error of the Compass. If the earth be a magnet, then it should have all the properties of a magnet. For instance, it should be capable of inducing magnetism in susceptible substances in its neighbourhood. It has this property, and it is found that steel masts and columns, pokers, hammers, and other objects of steel, are sufficiently magnetised to affect a compass appreciably. This is the result of induction by means of the magnet we call the earth.

This is a phrase used by Lord Kelvin in order to describe the influence upon a ship's compass of the ship's own magnetism. All the soft iron of a ship is magnetised by the earth's induction, though this magnetism is only temporary and not important. On the other hand, all the steel of the ship and its hard iron acquire a more or less permanent magnetism, the exact nature of which depends upon various factors, such as the position in which the ship lay while it was being built. This permanent magnetism of the ship is a very serious matter, and may mean the difference between life and death for the sailor.

The Greatest Inventor in History. It is not necessary here to describe the various kinds of error which the permanent magnetism of the ship may induce in the indications of the compass. But we must celebrate once more the great name of Lord Kelvin, that mighty genius whose practical inventions alone constitute him, perhaps, the greatest inventor in history, while his contributions to pure science would suffice to immortalise a dozen men.

The Thomson or Kelvin compass is now to be found on every ship that sails the seas, and no one can say how many lives it has saved or what worth of cargo. Among the distinguishing properties of the instrument we may briefly note the fact that the Kelvin compass contains six or eight magnetised needles instead of one, and that the various kinds of errors of the compass are corrected by means of appropriate apparatus, such as bar magnets, horizontal and vertical, the position of which can be altered, and balls of soft iron, which are fixed on to the binnacle at the level of the card of the compass, and which neutralise the magnetism induced by the earth in the soft iron of the ship.

The Field of a Magnet. We have already seen that in the neighbourhood of a magnet there is some essential difference from the conditions which prevail further away. The area over which the magnet exercises its influence we may describe as the *field* of the magnet. We have already noted facts from which we may properly infer that the earth itself, being a magnet, has a field in its immediate neighbourhood. And this is so. The existence and some of the characters of a magnetic field may be shown by spreading some iron filings evenly upon a sheet of paper underneath which lies a magnet. If we tap the paper we find that these filings arrange themselves along a series of curved lines passing between the two poles of the magnet. These curved lines are known as *lines of force*, and their study is extremely complicated and interesting. The appropriateness of the name will be seen if we make a further experiment, which consists in lowering a small magnetised needle over the paper and seeing what happens to it. Its point will be found to follow one of the lines of force already indicated by the position of the iron filings, and if the north pole of the needle be downwards it will be driven towards the south pole of the magnet.

Continued

CARPENTRY WORK IN ROOFS

Lean-to, Collar, King, and Queen-Post, Compound, and other Forms of Roof. Arrangement and Dimensions of Timbers

CARPENTRY continued from page 4116

By WILLIAM J. HORNER

THE carpentry work in roofs consists in the erection of the wood framework to which the slates, tiles, sheet metal, or other covering is attached. Roof work is not now so entirely the province of the carpenter as it formerly was. Very large roofs are built of iron or mild steel, with no woodwork about them. In timber roofs the ties, or members that are subjected to tensile stress, are often of iron. In no case is wood used as exclusively as formerly, when even the pins that united the timber joints were of wood.

No matter what the shape or size of a roof may be, the carpenter has to provide for and arrange a series of rafters 12 or 14 in. apart over the entire surface. If the length of these exceeds about 8 ft., intermediate support must be provided for them. Generally they run from the roof ridge or apex down to the eaves, but occasionally the horizontal position is adopted. For convenience in attaching the roof covering, it is generally necessary either to board the rafters entirely over or to nail on a series of strips transversely, the former method being best.

Different Classes of Roofs. When the span from wall to wall does not exceed 16 or 18 ft., the carpenter's work is of a much simpler character than in larger spans. This is because of the necessity of supporting long timbers at intervals, since it is more economical to provide intermediate supports for comparatively slender timbers than to render them independent of intermediate support by greatly increasing their section and weight.

Roofs, therefore, may first of all be divided into two classes—those in which rafters alone are used with suitable woodwork to which to attach their ends, and those in which an elaborate skeleton-work of wood must first be built up for the rafters to rest on. Those in the first class are suitable for sheds and very small buildings of various kinds, including small dwelling-houses. Those in the second may be divided into *king post* roofs, suitable for spans between 18 and 30 ft., *queen post* roofs for spans between 30 and 45 ft., and *compound* roofs for spans of more than 45 ft. There are also a few forms simpler than the king post which come between that and the simple rafter roof, and there are some other forms suitable for moderately large spans, which do not fall under either of these classes.

The Lean-to Roof. The single slope, or *lean-to* roof [**241**], for a span of not more than 10 ft., may be constructed only of rafters extending from one wall to the other at the necessary slope. In roofs so small that the distance from ridge to eaves is less than 6 or 7 ft., it is not necessary to use rafters at all, but simply to board the surface over, providing a suitable support at top and bottom for the ends of the boards to bear on. The boards in such a case should run with the slope. When laid on rafters in the ordinary way, they run transversely to the slope, which, as far as throwing off wet is concerned, is not so satisfactory a position. Sometimes in medium and large roofs boards are laid diagonally on the roof surface, the main idea in this being to make them act as diagonal bracings to the other parts of the roof framework. The advantage, however, is only slight, and there is considerable waste and extra work in fitting them in this way.

Wall Plates. In the lean-to roof, when rafters are used, a bar of wood, or *wall plate*, as it is called, is fixed along the top of the lower wall flush with the inside edge, and the lower ends of the rafters are fitted with a birdsmouth joint [**242**] and nailed on to it. At the upper ends attachment of the rafters to the wall is more troublesome, but it should be done securely to reduce outward thrust on the lower wall. A wall plate may be either built into or attached to the back wall at the desired height, and frequently bricks are removed or recesses chipped for the ends of the rafters to enter into, as in **243**. When this wall plate is not built into the wall, it may be bolted or nailed to it, or may rest on a projecting course of bricks built in for the purpose. Or another good method is to nail short lengths of hoop iron to the wood, leaving projecting ends of the iron, which can be built in between bricks as the wall is erected. With a wall plate securely attached the rafter ends are often not let into the wall, because it is always advisable to leave ends of timber exposed to the air as much as possible to preserve it from decay and dampness.

The section or scantling of the rafters will depend on their length, and ranges from $1\frac{3}{4}$ in. to $2\frac{1}{2}$ in. wide, by 3 in. to 6 in. deep. On these the transverse strips or boards are nailed to take the roof covering.

A simple roof of this kind is limited to spans which do not exceed 9 ft. or 10 ft., but the same class of roof may be employed for considerably greater spans if suitably tied and braced.

Fig. **243** shows how a horizontal beam may be introduced at the base of the roof, and, if desired, a vertical post at the back, so making a rigid triangular frame which will exert no outward thrust on either wall. The dotted lines also

show how a brace or strut might be introduced to afford support to the central part of the rafters, and if desirable a vertical tie might extend from there to the middle part of the horizontal beam. Generally, however, if the span be large enough to require this, the couple roof is adopted instead.

Function of Wall Plates. The purpose of wall plates is to distribute the weight of the roof uniformly on the wall instead of at intervals on the individual bricks upon which the rafters would otherwise have to bear. They are generally about 3 in. deep by 4½ in. wide, or in large roofs 6 in. by 9 in. They are generally spiked on the wall flush with the inner face, to avoid increasing the span. Sometimes two wall plates are used parallel with each other with a space between. When the lower ends of the rafters project over the wall it is sometimes necessary to have the wall plate flush with the front, as in **244**, and notch the rafters on to it. Another method is shown in **245**. Often in large roofs the wall plate is not continuous, but short plates, or *templets*, as they are called, are inserted for the roof trusses to rest on, the rafters themselves bearing on a pole plate, which will be described later. These templets are about 30 in. long and sometimes are of stone or metal instead of wood. The usual form of joint for wall plates, when it is necessary to join timbers end to end, is that shown in **246**.

The Couple Roof. The couple roof [**247**] reduces the length of the rafters by one half, and consequently increases their strength, thus enabling a larger span to be bridged without increasing the section of the rafters. The weak feature in such a roof is that its weight does not bear vertically on the walls but tends to thrust them apart; and as it is easy to modify its form so that all, or a great deal, of this outward thrust is prevented, the simple form in **247** is seldom employed for much larger spans than the lean-to roof, unless the walls are low or are thickened or buttressed to withstand it. As far as the strength of the rafters themselves is concerned, 12 ft. may be regarded as the maximum span for which this roof is suitable.

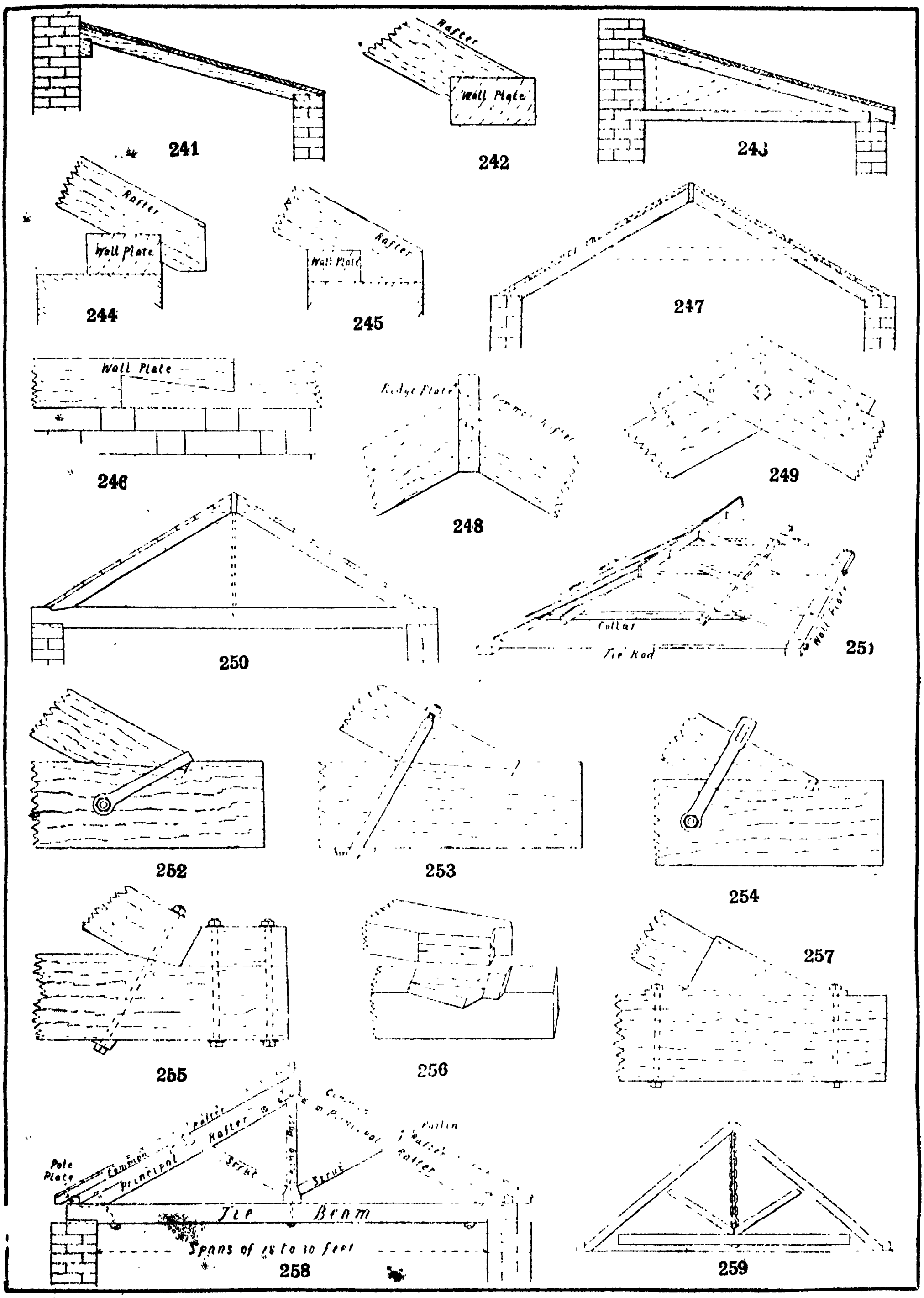
The Collar Roof. It may be strengthened and made suitable for larger spans by connecting the opposite rafters with a collar, as dotted in **247**, which acts either as a brace or a tie to the rafters according to whether their lower ends are rigidly fixed or free to spread. It is called a *collar* roof and would usually be adopted for spans between about 10 ft. and 14 ft. A short collar immediately under the ridge plate, as shown dotted in **250**, also adds to the strength of any roof of this kind.

In collar roofs the lower ends of the rafters are birdsmouthed on to a wall plate and the top ends bevelled to bear against the ridge plate, which is placed between [**248**]. The function of the latter is to provide a straight and continuous ridge along the top of the roof. Fig. **249** shows an alternative method. The rafters are nailed at their ends to the wall and ridge plates. The collar may be either nailed or held by a bolt to the rafters. Sometimes the joint is made more secure by halving the parts together, generally with a dovetail halving, but this is hardly advisable because it weakens the rafter at a point where it needs to be as strong as possible. In the ordinary collar roof the position of the collar is half way down the rafters. The lower the collar is placed, the less outward thrust the ends of the rafters can exert, and when placed absolutely at the base, as in **250**, it ties them completely.

The Couple Close Roof. The roof is not then called a collar roof, but a *couple close* roof, because it has two slopes closed by a tie at the base. In this form, unless a collar be added as well, the middle portion of the rafters loses the support which the collar would afford; but the main reason why a collar half-way up is used, if possible, in preference to a tie beam at the base is that the latter in a low building is often too much in the way or too unsightly. It also, of course, consumes more material and adds to the weight of the roof, for although the tie beam is in tension, it is necessary to make it of considerable depth to prevent sagging in the middle, and the greater its length the greater must its depth be.

In either of these roofs it is not essential that every pair of rafters should be tied. The connections may be only at alternate ones, or at longer intervals. In some cases the wall plates instead of the rafters may be tied. Fig. **251** shows wall plates tied by iron rods, and some intermediate rafters resting on purlins which are supported by collars at intervals. When the wood tie beam is employed it forms the base on which the lower ends of the rafters rest, and it extends several inches beyond the rafters at each end, so that a suitable joint can be made between them. The forms of joint generally employed were shown in **168** to **171** [page 4043], but the methods of holding it together vary with the size of the timbers. Further examples of these joints and fastenings are shown in **252** to **257**. Sometimes the parts are halved together, but a joint in which the rafters bear their entire section on top of the beam is best. When the rafter bears on the tie beam within the inner face of the wall, a stub tenon [**170**, page 4043], with its front at right angles to the body of the rafter, and tapering to nothing at the back, is generally most satisfactory because very little material is cut from the tie beam. If the rafter bears immediately over the wall, as it always should do if possible, a stronger joint can be made by cutting more from the beam, which is then better able to withstand the consequent weakening. A bridle joint [**167** and **256**] is sometimes preferred to a tenon, but it weakens the beam more than the latter and does not transfer the lost strength to any other part. Its only advantage is that there are no hidden parts which may not be in contact and taking their share of the stress.

The ends of the tie beam generally have a bearing of about 9 in. on each wall, and it is prevented from moving by being either spiked, cogged, or dowelled on to the wall plate. In small roofs it is customary only to nail or spike



TIMBER WORK IN ROOFS

241. Lean-to roof **242.** Birdsmouth joint **243.** Lean-to with tie beam **244** and **245.** Rafters notched over wall plate **246.** Wall plate joint **247.** Couple roof **248.** Ridge plate **249.** Alternative to ridge plate **250.** Couple close roof **251.** Wall plates tied **252-257.** Joints between tie beam and rafter ends **258.** King post truss **259.** Illustration of principle of king post truss

it. A cogged joint was shown in **177** [page 4043]. The thickness of rafters and tie beam are usually the same, but the depth of the latter is generally greater because it is longer. If it acts as a joist for supporting a ceiling as well as being a tie beam for the rafters, then its depth must be increased accordingly. The rafters range from 3 in. to 6 in. in depth according to the size of the roof; 8 ft. is reckoned about the average length over which they can be allowed to extend without intermediate support, and their section then should be about 5 in. by 2 in. For a span of 12 ft. without intermediate support, which is the most that can be attempted with economy, their section should be about 7 in. by 2 in. or 6 in. by 3 in.

The King Bolt. In roofs of ordinary slope, which is about 30 deg. with the horizontal, the tie beam is the longest member and the first to need support at the centre. From 10 ft. to 12 ft. without support is generally considered as much as is advisable, but this is frequently exceeded in roofs where the total span is only a few feet more. When the span exceeds about 15 ft., the simple couple close type is abandoned and a vertical tie introduced connecting the ridge of the roof with the horizontal tie, as shown dotted in **250**. This prevents the horizontal from sagging in the middle, and leaves the weakest part of the frame then at the middle of each rafter. This is suitable for spans of as much as 18 ft., but beyond that the rafters need bracing and the king post truss is introduced.

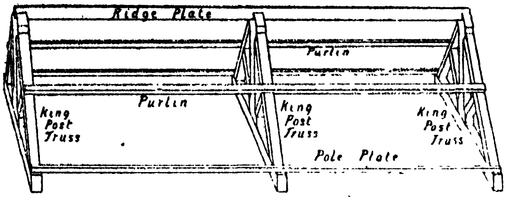
The King Post Truss. For spans of more than about 18 ft., what is known as the *king post truss* [**258**] is employed, and this is so satisfactory an improvement on the preceding types that it is suitable for any spans up to 30 ft. In this the tie beam is supported in the middle by a vertical tie called the *king post*, and the rafters are supported in their middle by struts or braces from the base of the king post. It is obvious that this makes a very rigid frame, but the reason why that arrangement is best is not so apparent until the part which each member plays is considered. It would scarcely be supposed at first that the vertical member, or king post, was subjected only to tensional stress, yet it is a fact that it is entirely in tension. The diagonal struts, on the other hand, are entirely in compression. Of the outside frame members the horizontal beam is in tension and the rafters in compression, as in the previous forms described. The stress on the rafters, however, tends to bend and break them inwards, and consequently, as with the tie beam, their depth must be greater than their thickness. The struts, being subjected to compression with no definite transverse strain, will bend according to the direction of their least dimension, and consequently should be made as nearly as possible square in section, and not less either way than $\frac{1}{20}$th of their length. As straps are seldom employed on the struts, it is often best in large trusses to make them less in thickness than the posts and rafters, thus saving material and weight in the roof without loss of strength.

To demonstrate graphically how the middle of the beam and the middle of each rafter receives support from the internal members of the triangular frame, we will suppose, as in **259**, a chain substituted for the rigid king post, and the beam and struts separated from the rafters, the latter being prevented from spreading at their base, and acting as a tripod in supporting a weight. It is then apparent how the vertical tie supports the beam and the struts the rafters. In practice, of course, a chain is never used, but either a wood post or an iron rod.

All the parts of the king post truss, with the exception, sometimes, of the struts, are generally made of uniform thickness because flat iron straps can then be bolted on the surface to hold joints together. This thickness ranges from about 3 in. for a small span of 18 ft. or 20 ft., to 5 in. for a span of 30 ft. In their other dimensions the members vary.

Rafters. The rafters employed in the composition of the king post truss are of larger dimensions than the rafters previously alluded to, and of different character. In the smaller types of roof only one kind of rafter is required, but with the king post truss two kinds of rafters are introduced—the *principal rafters* and the *common rafters*. The common rafters are necessary in all roofs, and are of the dimensions already stated. The principal rafters support the common rafters in trussed roofs. The reason of this is that king post trusses cannot be formed under each pair of rafters without making the woodwork of the roof needlessly heavy and involving a lot of unnecessary work. King post trusses, therefore, are set on the walls at intervals of about 8 ft. or 10 ft. apart, and are connected by transverse bars called *purlins*. At the apex they are connected by the ridge plate, which is let into the tops of the king posts, and at the base the tie beams are cogged on to the wall plates, and are also connected by a rail on top, of the same character as a purlin, but called a *pole plate*. This forms a framework [**260**] to which the common rafters can be attached, and which affords them ample support, so that they are not then required to carry a very great weight unaided. Sometimes trusses of different character alternate with each other, the heavier being used over buttressed portions of the walls, or to support heavier parts of the roof. The trusses are also known as the *principals* of the roof. The principal rafters are those which occur in the truss frames, and they have to be kept below the level of the common rafters because they carry the supports for the latter. They range in depth from about $4\frac{1}{2}$ in. to 12 in., according to the size of the truss.

King Post, Tie Beam, and Purlins. Owing to the peculiar shape of the king post, it is necessary to reduce it from a piece of timber measuring about twice the width of the ultimate size of the central part. The exact size of the enlarged ends is got by marking the bevels of the rafter and strut joints, keeping them as nearly as possible at right angles to the inclination of those members. The arrangement of the king post joints is shown in detail in **261**. Iron straps are usually bolted across the joints to hold the



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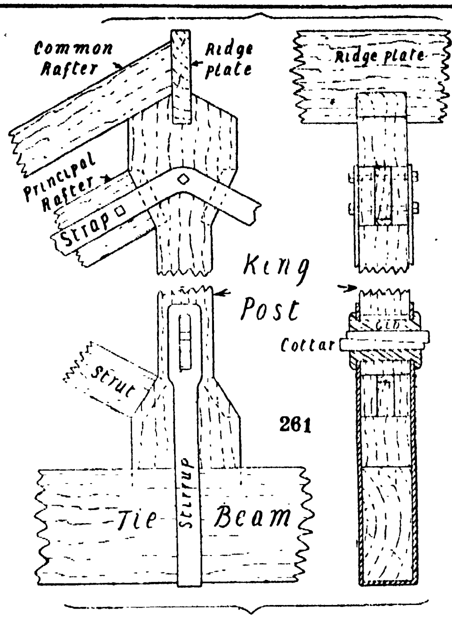

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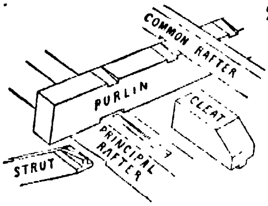

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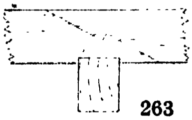

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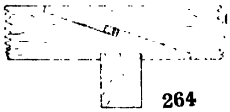

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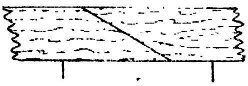

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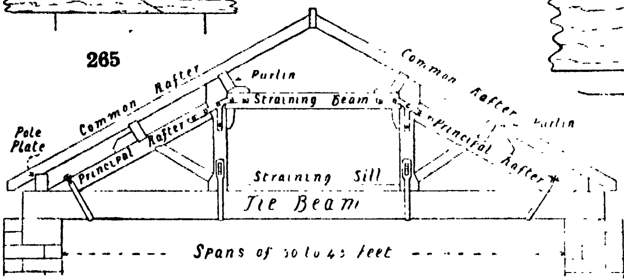

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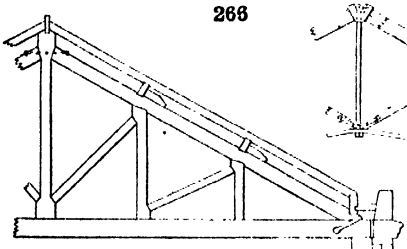

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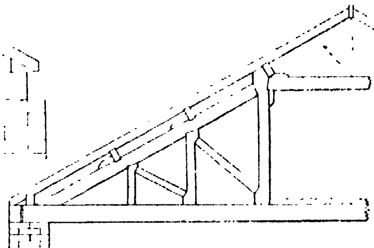

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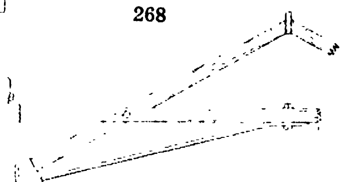

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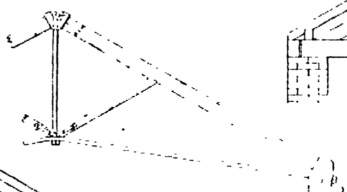

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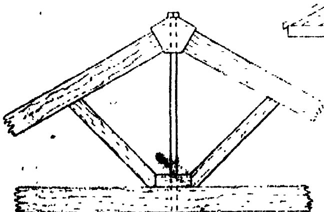

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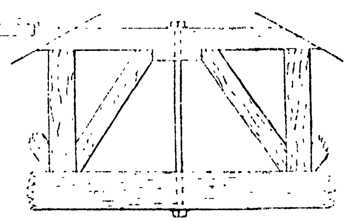

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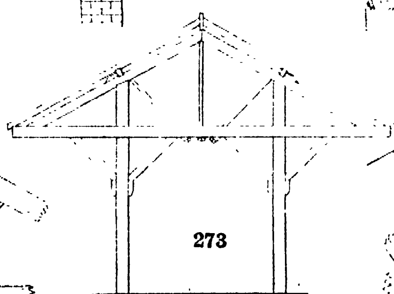


273

TIMBER WORK IN ROOFS

260. King post roof before common rafters are put on **261.** Details of king post joints **262.** Joints of rafters and purlins **263-265.** Joints in purlins **266.** Queen post truss **267 and 268.** Compound roofs **269 and 270.** Roofs with sloping ties **271 and 272.** King bolt connections **273.** Roof supported by posts

members together, and the stirrup which supports the tie beam is generally tightened by folding wedges through the post, as shown. Sometimes a bolt is inserted instead, as shown dotted in **258**. In heavy timbers a cast-iron socket receives the base of the king post and the diagonal struts. The tie beam is given about ½ in. of camber to 10 ft. of length.

The purlins, or horizontal rails, on which the common rafters rest, are generally put immediately over the tops of the struts, as in **258**, and as there are only two struts in a king post truss, the purlins are consequently two in number also, occurring on the middle part of the rafters. At the top the common rafters are fitted and nailed to the ridge plate, and at the bottom another rail called a *pole plate*, is nailed on top of the tie beams or on the lower extremities of the principal rafters [**258** and **267**]. On to this the lower ends of the common rafters are birdsmouthed and nailed. The purlins are notched or recessed ½ in. or so to fit over the principal rafters and nailed on, and further to prevent them from slipping or turning over under the downward pressure a block or cleat is fixed below for them to bear against [**258**]. Details of these joints are shown in **262**. In ordinary work the cleats are usually merely nailed on the surface, without being fitted, as shown. Examples of end joints in purlins are shown in **263** to **265**. The common rafters are notched to fit the purlins. The stirrup, tightened by folding wedges [**261**], is the best method of connecting the king post and tie beam. The bolt [**258**] is suitable only for small trusses. To insert it, a hole has to be bored up the centre of the post, and a slot cut in one side to insert the nut, after which the opening is plugged.

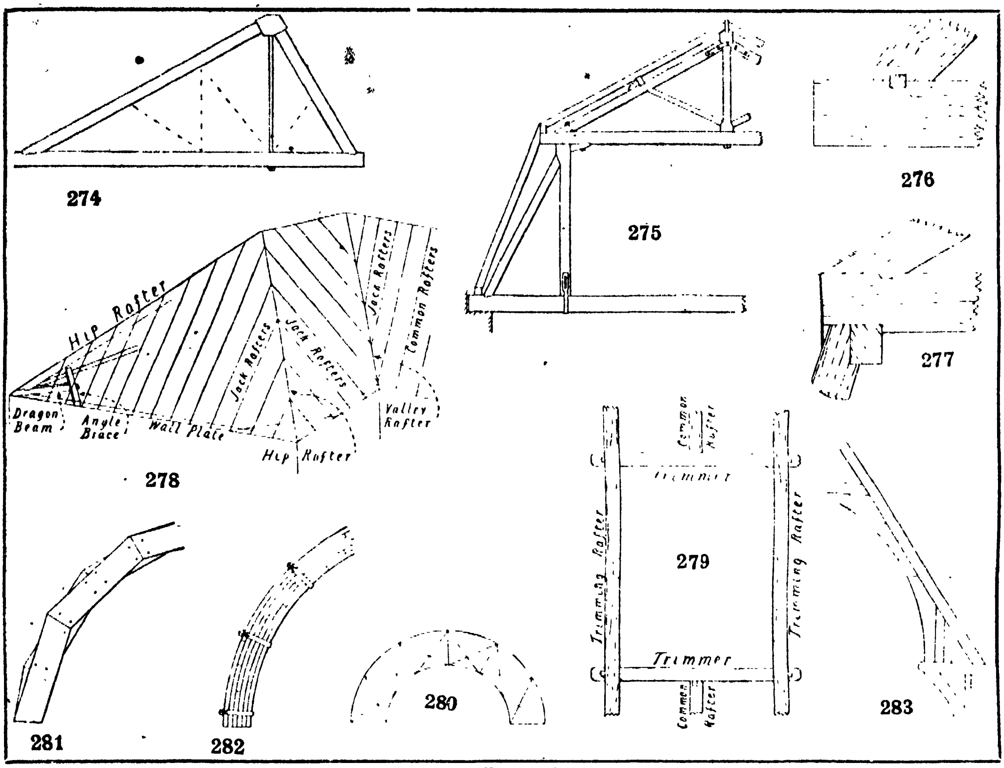
Heel straps [**252** to **254**], or a bolt [**255** and **258**] are employed to hold the principal rafters to the tie beam. Sometimes the strap is put on at right angles to the inclination of the rafter, and so holds the joint directly together, and sometimes the angle is increased, as in **252**, so that it acts as a tie to the thrust of the rafter. At the head of the king post a bolt is sometimes used, as dotted in **267**, but more generally straps [**258**], or sometimes plates. The truss should be put together with the king post slightly short and the struts full to length.

The Queen Post Truss. In spans of from 30 ft. to 45 ft., the beam and rafters are supported at two intermediate points in the length instead of at one only, and the arrangement of ties and braces for doing this is called a *queen post truss* [**266**]. The middle, or king post, is abandoned, and two shorter ones, called queen posts, are introduced, one on each side, at some distance from the roof centre, thus supporting the tie beam in two places. These two posts are connected at their tops by a horizontal member, called a *straining beam*, and the junction of these affords support at one point for the rafters. It will be seen in **266** that the principal rafters end at this point, and do not continue to the top of the roof as in the king post truss. A strut from the base of each queen post affords support to the middle of each principal rafter, and the purlin over this point occurs about a third of the distance up the common rafter, the next purlin at the top of the queen post being another third. The queen post joints do not differ essentially from those of the king post, except so far as the difference in arrangement requires it. As in the king post truss, it is convenient to have the members of similar thickness so that flat straps or plates can be bolted across the joints. A useful rule by which suitable thicknesses for any given span may be obtained is given in G. P. Allen's "Practical Building Construction." For a king post truss divide the span by 5, and call the quotient inches, which will be the thickness of the truss. For a queen post truss, divide the span by 8, which will give the thickness in inches. Suitable dimensions, both thickness and depth, are given in the table on preceding page.

Compound Roof Trusses. For spans of more than 45 ft., compound trusses are employed, consisting of a combination of king and queen post trusses, and as many additional vertical ties with corresponding struts as may be required. There is no limit to the extent to which this may be carried, but in practice the horizontal tie beam is generally abandoned for other forms of truss, or the roof is broken up in a number of slopes, receiving support from below by pillars or walls when the area covered is very great. When the queen post alone is not

DIMENSIONS OF TIMBERS FOR ROOFS

Span in feet.	Tie beam.	King post.	Queen posts.	Princess posts.	Principal rafters.	Straining beam.	Struts or braces.	Purlins.	Common rafters.
	Deep Wide	Deep Wide	Deep Wide	Deep Wide	Deep Wide	Deep Wide	Deep Wide	Deep Wide	Deep Wide
10	4 × 2	..	..	..	..	..	..	..	3½ × 2
15	5 × 2½	..	..	..	..	..	..	..	4½ × 2½
20	9 × 4	4 × 4	..	..	5 × 4	..	4 × 4	7 × 4	3½ × 2
25	10 × 5	4 × 5	..	..	6 × 5	..	4 × 4	7½ × 4½	4 × 2
30	11 × 6	4½ × 6	..	..	7 × 6	..	4 × 4¼	9 × 5	5 × 2½
35	11 × 4½	..	5 × 4½	..	8 × 4½	7 × 4½	4 × 4½	8 × 4½	4 × 2
40	12 × 5	..	5½ × 5	..	9 × 5	8 × 5	5 × 5	9 × 5	4½ × 2
45	13 × 5½	..	6½ × 5½	..	10 × 5½	9 × 5½	5 × 5½	10 × 5	5 × 2½
50	13 × 6	..	6½ × 6	2½ × 6	10 × 6	8½ × 6	5 × 6	10 × 5	4½ × 2
55	14 × 7	..	7 × 7	2½ × 7	11 × 7	9 × 7	5 × 7	10 × 5	5½ × 2
60	15 × 7½	..	7½ × 7½	3 × 7½	12 × 7½	10 × 7½	5 × 7½	10 × 5½	6 × 2½



TIMBER WORK IN ROOFS

274. Sawtooth roof **275.** Mansard **276** and **277.** Details of joints **278.** Hipped roof **279.** Trimming **280.** Arched roof **281** and **282.** Timbers for arch **283.** Hammer beam

sufficient, a king post is frequently inserted as well, either as in **267**, or between the roof ridge and the straining beam, as dotted in **268**, using a pair of struts from its base if desirable. The next step in a compound roof is to introduce another pair of posts outside the queen posts [**267**], also using struts from their base if required. Other posts or vertical ties may be employed.

Trussed Members. Purlins, ridges, or rafters may be trussed as an alternative to supporting them at frequent intervals, or to making them of sufficiently large section to extend long distances without intermediate support. The ordinary king or queen post trusses may then either be dispensed with entirely, or placed at great distances apart. Purlins are often trussed when the distance from wall to wall is hardly sufficient to justify the use of a transverse truss midway between. Rafters are not often trussed, because they are so numerous, and supports are more economical. Ridges require it only in exceptionally long spans.

Objections to the Tie Beam. The horizontal tie beam at the base of roof trusses is regarded more or less as a necessary evil. The one great point in its favour is that it ties the roof base and relieves the walls of lateral strain. The objections to it are that it obstructs a great deal of space in the interior of buildings, thus often making it necessary to build higher walls; while in very large spans it becomes economically, if not practically, impossible, because of the enormous weight of material necessary to form trusses of the required strength. The horizontal tie beam, therefore, which is the main element of the triangular-shaped truss, is often discarded, even in small spans, for ties which slope upward, **269** being a common example. In some of the early wood roofs similar methods were adopted, but such ties are now usually of iron. Horizontal ties of iron are also often employed instead of the wood beam, but when ceiling joists have to be attached to the under surface, the wood beam is more convenient.

In **269** a collar is employed to impart rigidity to the rafters, and to its central part the tie rod is bolted. In **270** a king bolt is employed to support the tie rod and two struts, thus making a stronger truss suitable for larger spans than **269**. Figs. **271** and **272** show methods of employing iron king bolts instead of wood posts. Fig. **273** shows an arrangement for another kind of roof supported by posts instead of walls; **274** is an example of a sawtooth or weaving-shed roof. The last, however, are generally constructed entirely of iron. They are commonly employed for factories, and are arranged in a series instead of one span over the building. The long part of the slope is slated, and the short, steep part fitted with glass and facing the north so that the interior of the building gets a steady light without sunshine.

The Mansard or Curb Roof. The *mansard* or *curb roof* [275] is a peculiar form of roof often employed, especially for dwelling-houses. In this case the horizontal tie beam at the base is retained, but the space above it utilised. In ordinary direct sloped roofs the space above, although large, would not be of much value for rooms because of the sharp slope of the sides. In the mansard roof this is overcome by making the sides nearly vertical for some distance up, and then avoiding a very high and acute roof ridge by altering the angle to a very low one. In large spans the king post truss is employed for the upper part, with posts and struts at the ends between the upper and lower tie beams. Fig. **276** shows a method of joggling a strut to a beam, often adopted in the mansard roof. Fig. **277** shows another method of arranging the rafter and strut in a mansard, so that instead of the slates meeting where the angle changes, there is a drop from one slope to the other. In small spans there is no king truss in the upper part, but the rafters are tied by a collar.

Hipped Roofs. *Hipped roofs* [278] are very common, and considerably complicate the carpenter's work. Instead of having a vertical or gable end from which to begin the line of rafters, the roof is sloped at the ends as well as the sides of the building, and the rafters have to be arranged accordingly. This necessitates a stout diagonal rafter, called a *hip rafter*, from each corner of the walls to the end of the ridge plate, and the common rafters have to be cut to the correct length and angle to meet this, as shown in **278**. A valley, also shown in **278**, is the reverse of a hip, and is also frequently necessary. In small roofs what are known as a *dragon beam* and an *angle brace* are employed to prevent the outward thrust of the hip rafter from acting directly on the corner of the building. The arrangement is roughly shown in **278**. The angle brace bridges across the corner at some distance back from where the walls meet, and is securely attached to the wall plates. The ends of the wall plates are half lapped, and the short dragon beam is notched over this and extends back, and is tusk tenoned into the middle of the angle brace. The base of the hip rafter is notched and stub tenoned into the dragon beam. In large roofs the hip rafter is trussed instead of a dragon beam being employed.

Trimming. Where chimneys, skylights, dormer windows, or other openings in a roof occur it is generally necessary to trim the rafters in order to leave sufficient open space. As it is very seldom that entire rafters can be omitted, it is necessary to provide support for the ends where a portion of their length has been removed. This is called *trimming*, and the transverse piece that supports the ends is called a *trimmer*. Occasionally the opening can be made immediately above or below a purlin, or between two purlins. But the usual method is shown in **279**. The trimmers are tusk tenoned between two rafters, which are generally ½ in. thicker than the others, and are called *trimming rafters*. The ends of the intervening rafters that have been trimmed are tusk tenoned or notched into the trimmers, which are of the same section as the two trimming rafters. A frame of the desired size is thus provided in the roof surface without any rafters crossing it.

Other Varieties of Wood Roof. Among types of roof without horizontal tie beams there are several that have been popular when wood was the only material available, but in most of them either an enormous amount of work is involved or strength is sacrificed to appearance; besides which, the walls often had to be made much thicker to sustain them than is the custom at present. It is obvious that an arched construction like **280** needs no tie at all to enable it to support itself and to exert no outward pressure at its base. As the only way of forming curves of great length in wood is to build them of a great number of pieces breaking joint with each other, that method has been adopted to form arched roofs of timber. The two most popular varieties of this kind have been built of timbers joined as in **281** and **282**; but outside of these straight slopes have been required to stiffen the curved interior and to carry the roof covering. There are also numerous arrangements adopted in temporary centring for arches that are suitable for roofs.

Another variety of roof without a tie at the base is known as the hammer beam [283]. It is best suited for high-pitched roofs of not very great span. It throws considerable strain on the walls, which must be made thick enough to withstand it. Wood roofs without tie beams, however, are exceptional, because they can be better and more cheaply built of iron. In very large spans also wood cannot compete with iron. The principle on which such roofs are built is that of the arched girder strengthened by tie rods, and there is usually no carpentry about them.

Domical, conical, and polygonal roofs are occasionally required, and form very light and strong structures. Their rafters or ribs meet at a common centre at the apex, and radiate outwards and downwards to the wall plate, which extends entirely round the top of the wall. Shorter rafters may be employed between as the circumference increases, and transverse ribs or purlins where necessary. Interior ties and braces are often adopted, but in small roofs are not necessary. A domical roof requires curved or arched ribs, and when these are of wood they are made in the same way as **281**, and the outer and inner edges cut to the sweep.

Drips, Falls, and Gutters. Some amount of woodwork is generally necessary on which to lay lead or attach gutters for carrying off water. For the details of this the carpenter is generally dependent on the plumber's instructions. In roofs with overhanging rafters, as in **258**, **266**, and **268**, a fascia board is generally attached to carry a cast-iron gutter. In parapet and M-roofs, a flat or box gutter lined with lead is generally used, and to carry this, horizontal bearers are attached to the rafters or to the pole plate, as in **267**, and boarded over to lay the lead on, a slight slope being given to the gutter lengthwise.

Continued

HOW TO DRESS & BE HEALTHY

Healthy Skin and Ideal Clothing. Cleansing of the Skin and Hair. Baths. Clothing Materials. The Best Dress for Men and Women

Continued from page [illegible]

By Dr. A. T. SCHOFIELD

IT is unfortunately too generally true that cleanliness in clothes decreases as we near the skin. The collar and cuffs are frequently changed, the shirt not so often, the vest more seldom still, and the skin only thoroughly washed perhaps once a fortnight, and sometines not even then! The modern system of large baths in even small houses is an incalculable boon for the middle classes, while the public baths in most towns are so well appointed and managed as to bring cleanliness within the reach of all.

Impurities of the Skin. There are at least three impurities needing constant removal—the dried-up scarf skin of dead epidermal cells constantly being produced on the surface of the body, the continual secretion of oil and water from the glands and pores all over the surface, and the dirt which inevitably settles on the skin. Labouring men and porters, who stand much in need of baths and washing, have often more healthy skins than clerks and people in business. The reason of this is that they perspire frequently and excessively, and thus a good deal of the effete matter is washed away by a natural process. No cloth clothes or any garment that cannot be washed should ever be worn next the skin. They should be changed at least every week. The skin requires, however, often something more than merely to be kept clean. If it is at all delicate the face is apt at times to become hard and dry, wrinkled, spotted, or otherwise disfigured, often from preventable causes.

The best lotion or wash for a tender skin is pure *rain-water*, pure soft water, boiled water, distilled water, or artificial soft water, which can be made in any town where only hard water is laid on by putting at night in the ewer so much of Maignen's "Anti-Calcaire" as will lie on a halfpenny. In the morning, the water carefully poured off the sediment will be found beautifully soft and fit for the most delicate skin. For women no soap should be used for the face but pure curd soap, and, for delicate skins, prepared oatmeal, and, once a week, very hot water and a little curd soap. The worst thing for the face is hard water, and tar, carbolic, or strong yellow soap. Another way of making the skin of the face coarse and pimply is to use face powder.

The Turkish Bath. The Turkish bath, a great beautifier of the skin, is imported from the East, and in its English form is most safe and useful. Besides being by far the most effectual cleanser and pore opener that we have, it is a general restorative and tonic of the highest value. On brain-workers and residents in towns it confers the highest benefits. Taken weekly or fortnightly, it will be found beneficial in every way. There are some cases, however, in which it is dangerous, and medical advice should be first sought by anyone who intends to take it.

Cleanliness and Cheerfulness. Another result of the inaction of the skin which is very common is disease of the lungs, liver and kidneys. With a clean and healthy skin, the spirit is cheerful, the food is enjoyed and easily digested, exercise is a delight, the mind is calm, sleep quiet, and, in addition, there is a general moral elevation of the whole man. Drunkenness is rare amongst cleanly people.

How, then, is the skin best kept clean? First of all, by washing the body. This should be done every day with water, and once a week with soap. Sweeps, scavengers, sewer men, dustmen, many labourers, stokers, and blacksmiths get so dirty that it is necessary they should wash well all exposed parts at night with soap. In summer, water that has been standing in the room all night is quite warm enough to use.

Baldness is much more common amongst young men than women, and amongst the upper than the lower classes. This is partly due to the false idea that continual bathing of the head and brushing with hard brushes is good for the hair, and partly to the use of the tall silk hat, which is the worst enemy for the head ever devised. People are seldom bald excepting on that part which is above the level of the brim of the hat. It is not generally known that water does *not* promote the growth of the hair, but, on the contrary, injures it if too constantly applied. Under ordinary circumstances a man's head should not be washed oftener than once a week, and a woman's once in three weeks.

The Effects of a Cold Bath. Cold baths have a temperature of from 60° to 65°. They first of all drive the blood to the heart, thus greatly stimulating it and quickening the circulation; then the blood rushes back to the skin, producing a violent reaction. A cold bath at first somewhat depresses and then stimulates the system. In slight congestion of the lungs, liver, and brain it is very good when the reaction is brisk—not otherwise. In chronic joint disease the cold douche is very valuable. In bathing it is bad to stand in cold water up to the middle only; this produces too much congestion of the upper half of the body. Usually a person should not dress until the warm glow comes.

A cool bath, from 70° to 75°, is a great luxury in hot weather. The body should be dry-rubbed all over with a towel before entering the water. There is a gradual loss of heat for a while, followed by a renewed sense of vigour. A tepid

bath is another 10° hotter—80° to 85°—and, used in winter, is the same as a cool bath in summer.

A warm bath, from 90° to 95°, has a different effect altogether. It allays all pain and irritation, draws the blood towards the surface of the body, is a great sedative after fatigue, and a capital substitute for want of sleep. After travelling or exposure to the east wind it is very agreeable. It does good at the beginning of a cold, after illness, and after brain irritation. It is *the* bath for cleansing with soap and a flesh brush or flannel; it is good for aged people, and should be taken at any rate once a week, lasting from twenty minutes to half an hour, but not immediately after a meal.

The Ideal Bath. A hot bath, 100° to 105°, is a great stimulant of the system, but after a short time it rapidly exhausts the heart. It quickly relieves severe congestion of internal organs. After a hot bath, brisk exercise in the open air does not give cold. One of the most delicious combinations possible is to have a cold sponge after a hot bath.

If a bath at home is impracticable, there still remain the public baths. These are of three sorts—the plunge bath, the swimming bath, and the Turkish bath.

The plunge bath is for washing rather than for bathing, and, well filled with hot water, forms on the Saturday night an admirable conclusion to the week's toil. A cold shower bath is nearly always provided, and if taken at the end, and followed by a brisk rubbing with well-aired towels, is proof against catching cold on the way home. The swimming bath, regarded as still a luxury, will, we trust, soon be thought as much a necessity in every town and village as in the old Roman days. Of course, it may be abused. Boys or girls may remain in it too long, till they are blue and shivering; or silly and dangerous feats of strength and endurance may be attempted, resulting in some strain.

What to Wear. The purpose of clothes, from a sanitary point of view, is to cover the body so as to preserve it from feeling external changes of temperature, and to afford a general protection to the skin from wet and injury, as well as for adornment. In the present instance we are chiefly concerned with questions of warmth and protection.

Let us consider the essential qualities of a good clothing material, and then review those that are used and see which comes nearest to the standard with regard to warmth. A common idea is that clothes warm us. This they never do, of whatever material they may be made. It is we who warm them, just as we also warm our beds. The fact is, our bodies are exactly the right heat as they are, without any clothes, and if the temperature of the air were always about 90°, we should require no clothing for sanitary reasons; but as it is not, we want a material to isolate us from surrounding influences.

To be perfect, clothing material worn next to the skin should possess the following qualities: It should be *a bad conductor of heat*—that is to say, it should allow heat to pass very slowly through it in either direction. The effect of this is that in summer, when the sun is hot, it does not allow its heat to permeate through and warm our bodies too much; while in winter, when it is cold, it does not allow the heat of the body to escape and be lost. Such material we call cool in summer, and warm in winter.

The Qualities of Good Clothing. In the next place, such a material should be *porous*; it should absorb moisture, and at the same time allow the exhalation of the body freely to escape, be comfortable, and not too heavy or inflammable. We will, therefore, examine it as to eight main points.

1. CONDUCTION OF HEAT. What is wanted, seeing that our bodies themselves are kept the right heat by the blood, is isolation or non-conduction. When the external temperature is lower than blood heat ($98\frac{1}{2}$°) a non-conducting material keeps us warm. When it is above $98\frac{1}{2}$°, which is rare, a conducting material is warmer. Wool is the worst conductor, then fur, feathers, silk, cotton and flax. Flax is twice as good a conductor as wool, and hence has half the warmth. That is why ice is kept in flannel, and wool is used for tea-cosies and kettle-holders. Colour affects warmth by conduction. Black absorbs twice as much heat rays as white, then dark blue, blue, red, green, yellow. Hence white flannels in summer and coloured in winter are worn for games.

2. ABSORPTION OF WATER, OR HYGROSCOPY. Wool here leads with 170 parts of water as maximum, and a minimum of 110; then come silk, cotton and flax, with a maximum of 75, and a minimum of 41. Wool being most hygroscopic, is badly adapted for outer garments exposed to the wet, as it gets intolerably heavy when soaked; thus, a waterproof is better than an ulster.

3. EVAPORATION OF WATER. This is a very dangerous process in clothing, as it lowers the temperature rapidly; hence materials such as cotton, from which water evaporates quickly, are cold. Wool, on the contrary, has slow evaporation.

4. POROSITY (to air). Wool comes first, with 10, cotton 6, linen 6, wash-leather 5, silk 4, waterproof 0.

5. IMPERMEABILITY (to wind and water). The order here is fur, wool, silk, cotton, flax.

6. INFLAMMABILITY. Wool leads, then follow silk, linen, cotton.

7. ABSORPTION OF ODOURS. Wool absorbs most.

8. ELECTRIC QUALITIES. Wool generates currents and allows body currents to pass; then come, in order of their electric qualities, silk, wool, flax, cotton.

The Best Clothing Material. The best clothing material, therefore, is that which is the worst conductor, hygroscopic, with slow evaporation, most porous, impermeable, least inflammable, and with electric qualities.

Only one material—as, indeed, is now becoming well known—fulfils these conditions, and that is the natural covering of the sheep—wool. When properly manufactured, woollen garments are the most comfortable to wear next the skin; hence wool is now used as the material in making an immense variety of clothes. One sort of vest suitable for summer is like a fishing net, with meshes $\frac{1}{2}$ in. wide. Another is knitted like a

stocking, of varying thickness and fineness; it shrinks little and wears well. Ordinary flannel is a third sort, and may be had of any thickness or fineness. An inner garment should always be rather loose in fit and in texture, thus ensuring warmth and sanitation. Again, wool is the lightest material for clothing in proportion to the warmth it gives when dry, and thus for every reason it is the best for underclothing.

The same amount of clothing in separate layers gives more warmth than in one—that is to say, two thin jerseys are warmer than two thick ones. This is in virtue of the air between the two.

At night, except for quite young children, linen or cotton forms a better dress and more soothing to the skin than wool, the bedclothes making a sufficient protection against cold.

Wool is rough, heavy, dirty, shrinks, absorbs odours, and is expensive. Now, roughness is a real advantage in all sedentary occupations when the skin is sluggish; on the other hand, woollen cloths are now woven almost as smooth as silk. It is not strictly correct to regard flannel as heavy, for wool is the lightest *for the same amount of warmth*. It does not show dirt readily, and is thus considered dirty. Shrinkage is the most serious drawback, but can be avoided by the use of distilled water and a purely neutral soap (with no free alkali whatever). Woollen articles can be boiled, and by this process alone disinfected, for 15 minutes without damage. In ordinary water and soap they are either utterly destroyed or made like a board. There can be no doubt that on the whole the advantages of wool far outweigh its disadvantages.

Various Clothing Materials. *Fur* forms an invaluable article of clothing, being absolutely impermeable and a bad conductor of heat. It is such an absolute protector that great care is required in its use. *Leather* is admirable for motoring and all rough, exposed work. *Feathers* form light and warm articles of clothing owing to the amount of air they retain.

Silk is three times as strong as flax, and forms a most delicate and useful material for underclothing as well as dresses. It ranks in most of its good qualities next to wool, and surpasses it in its smoothness and electric qualities, but is most expensive. China silk contains no silk, but is China grass.

Cotton is made into every conceivable article of clothing. Under the name of flannelette, a pure cotton cloth is made to resemble flannel by raising the surface, so that it can absorb more air and give a warm feeling. Cotton is most inflammable.

Flax can be spun into linen almost as fine as silk, and cloth of every sort of fabric can be made, from the most delicate muslin to ships' sails.

Cotton and linen are both good conductors of heat, though linen is the better. Comparative power in losing heat is seen in the fact that while woollen fabric heated to 150 deg. loses 10 deg. in 12½ minutes, cotton loses the same amount in 9½ minutes, and linen in 7¼ minutes. The advantages of linen and cotton are that they are easily washed, are soothing to the skin, and are white, which wool never is; but they do not absorb water. The result is that they are cold, even on hot days, as they leave the perspiration on the wet skin, instead of drawing it off into the cloth.

Paper may hardly be considered as a clothing material; but it is of great value to the poor as a covering for beds, etc., and worn under the clothes, being a great non-conductor of heat, and thus very warm. It is also inexpensive, though not nearly so much used as it might be. The wearing of paper spread over the chest and buttoned under the coat answers the purpose of an overcoat. It makes a capital extra lining for boots, waistcoats, etc.

Dress for Men. With men, clothing is fairly rational and sanitary, and even among women, as we shall see, such advances in a right direction have been made that the strong language used against their dress by health reformers some years ago is now quite out of place.

The head is the only part of the body naturally clothed, and save for cleanliness needs no other covering. Indeed, it is far better bare than crowned with the chimney-pot hat. A tight-fitting tall hat is often really dangerous owing to the compression of the temporal arteries. All head coverings should be light and well ventilated. The ordinary hat weighs more than twice as much as a proper head-covering need do, while the want of ventilation produces a great and undue susceptibility to cold. An ordinary cap, a soft felt hat, a fur cap in extreme cold are all sensible head coverings devoid of danger. In summer a straw hat is admirable, and is both extremely light and well-ventilated.

The neck should be but lightly covered, and left free of all constrictions, for mufflers and neck wraps are frequent causes of cold and bronchitis. A beard is, of course, a great protection, unless it happens to be frequently wet and imperfectly dried.

Men's Good Sense in Dress. With regard to the body, the ordinary dress worn by men fairly fulfils the requirements of health. It is not picturesque, as a rule, but it is suited to our climate. The knitted woollen vest with long sleeves is a capital garment, also a knitted belt round the body as a protection against liver chills; so is the outer jersey or guernsey of sailors and fishermen. The coat and waistcoat of civilised life is a sensible attire for a variable climate, for if very cold the coat can be buttoned up, if warmer it can be left open, if hot it can be discarded altogether. Braces should always be used in preference to tight belts. It may be taken for granted that any garment that compresses any part of the body is harmful. The habit that working men have of tightly buckling a belt round the waist when hard at work is most injurious, and may lead to serious strains. No garters should be worn on the legs. Men's boots are, as a rule, sensible; only, the boot of the countryman is generally as unyielding as if made of cast iron, rendering perfectly useless all the elaborate muscles of the foot. A proper boot should follow the natural shape of the foot, should be elastic in the waist and sole, and have broad, low heels.

Bright-coloured socks or stockings should always be avoided, as even now they too often contain poisonous dyes. Leather leggings and puttees are better than waterproof coverings.

How a Woman Should Dress. The chief errors which occur in women's clothes are the results of the vagaries of fashion. In one or two respects even ordinary clothing greatly errs, but it is undoubtedly in fashionable dress that the greatest danger lies. Garments cut on health lines *only* are confessedly absurd ; for, after all, clothes have to fulfil many purposes, beauty being one of them. There are three great laws of health that must be obeyed in the dress of women, and they are : *No compression, no depression, no oppression.*

During the last twenty years there has taken place a revolution of the most beneficial character in the whole arrangement of a woman's underwear. The numerous petticoats and underskirts long considered so essential, which yet were so unhealthy and inconvenient, have well-nigh disappeared.

Since the hair of women is more plentiful than that of men, the need for head covering is less ; hence, as a rule, their bonnets and hats are light, and less protective.

With regard to the neck, a serious and common fault is to wear the collar of the dress far too tight. Another great fault is the very capricious way the neck is treated, at times thickly covered with fur boas and stoles, at others uncovered. When it is habitually left bare, the neck soon gets as hardy as the face.

Over the under-garment should be worn a well-fitting, but not tight, flexible corset. The corset, made of flexible material, is a useful support to the yielding form of women, though an unmitigated evil to growing girls in hindering the growth of the muscles of the back and producing weakness and curvature in that region. To adults its great evil is not so much in its use as in its abuse. Corsets can be worn without tight-lacing.

The Abuse of Corsets. Let a tape measure be passed round the narrowest part of the corset, and then round the narrowest part of the body when the corset has been removed. If the latter measure exceeds the first, the person undoubtedly laces tightly ; for, to say nothing of the thickness of the corset, which should therefore measure quite an inch more instead of less than the waist, some allowance should, strictly speaking, be made for breathing.

Now, what are the real evils of compressing these lower ribs by corsets and thereby forming an artificially small waist ? In the first place, the particular part of the body that has been selected for squeezing down to seventeen or eighteen inches is, unfortunately, the most important in the body. If the staylace wound about this part could be drawn tight enough to pass through the body, it would pass clean through the stomach, liver, and spleen ; it would divide the bases of both lungs, and just miss the heart above and the kidneys below. It would divide the main blood-vessels and nerves of the body. It would also cut right across other organs, such as the pancreas and duodenum. Now, it is a literal fact that even a moderate amount of compression indents the liver with the shape of the ribs, produces shortness of breath, palpitation, and dyspepsia, while, if carried to excess, the ribs may be dislocated, the liver nearly cut in two, and the severest diseases set up.

The natural size of a woman's waist varies from 24 in. to 26 in., and all the generations of tight lacing have not been able to make it smaller.

Another evil is the use of heavy woollen skirts and underskirts tied round the waist, and hanging from it. The evil here is not compression, but depression of the internal organs. No strings should be fastened about the middle of the body, but a well-fitting bodice of some stout material should be worn over elastic corsets sufficiently supplied with buttons for the suspension of all the lower garments. Care should be taken to see that the clothing is not too tight under the armpits, across the chest, or on the arms.

Boots. As to boots, the modern French article is quite on a par with the Chinese boot. The only article worth calling a boot, and pretending to be a rational covering for the foot, is one in which the instep or tread is as broad as the tread of the foot, and where the toe follows to some extent the natural outline. The general fault about boots is that they appear to be made for the hand rather than for the foot, for the longest part is in the middle. This is so with gloves and the hand, but in the case of the boot the longest part is at the big toe, on the inner side, and only boots thus shaped are right. Most boots also are too small ; yet it must be remembered that when the weight of the body is pressed on the foot as in walking, it increases one-twelfth in length and one-eighth in breadth. Some square-toed boots are, however, even greater delusions in their way than pointed toes, as the former may be very square at the end and yet too narrow higher up. The great point is to see that the boot is as broad as the foot at the tread. The curve of the inner side should be very slight, and the heel of the boot must be low and broad to give comfort in walking. Attention to these matters, and the wearing of woollen stockings, will preserve the foot from chilblains, corns, and bunions. The waist of the boot, and the soles, as has been said before, should be perfectly flexible, any rigidity destroying the natural spring of the foot.

Dress and Good Taste. We urge our readers to choose their dress judiciously, and to be assured that it is far better taste and far more important to study quality than appearance. Let the hat be plain and serviceable enough to stand a shower. Let the dress be of good material and not too heavy or weighted down with useless flounces or trimmings. Let the underclothing especially be of wool, loose and warm. Let the boots be strong and well shaped. Let everything be good of its kind. It is a matter of regret that in this country so few dress plainly and according to their occupations.

Continued

TOOLS OF THE SCRAPING CLASS

Scrapes. Milling Cutters. Drills. Counterbores. Boring Tools. Boring Bars and Heads. Reamers

continued from page 4154

By JOSEPH G. HORNER

BEFORE we proceed farther with tools which, though classed among cutting instruments, operate mostly by scraping, it will be desirable to consider the action of the scrape.

Action of Scrapes. The difference between a cutting and a scraping tool has been already explained thus—that the former has a very pronounced incisive or penetrating, wedge-like action, while the latter has not. If we look at a chisel [16], and then again at a common woodworker's scrape [17], the distinction is very apparent, the former cleaving the wood, getting well beneath the surface, the latter operating only to an infinitesimal degree below that surface. When the scrape is coerced, there is a very slight amount of penetrative action exerted, but it is so slight that any attempt to force the thick tool sensibly below the surface is in vain, and results only in the production of excessive friction and of heat.

Fig. **18** is typical of the mode of application of most scraping turning tools used for metal, top rake being entirely absent, and a clearance angle only being given to prevent undue friction and heating. Similar angles are employed in the scraping tools employed by wood-turners. An exception to this is the woodworker's scrape [**17**], in which there is actually a very slight amount of top rake imparted by the burnishing or sharpening of the tool, the edge being just slightly turned up by that act, and forming, while it lasts, a minute cutting edge. This is somewhat exaggerated in **17**, but the penetrative power is not like that of the chisel, or plane iron.

The Value of the Scrape. The advantage of the use of the scrapes for wood [**17**] and for metal [**18**] is that they are capable of finishing surfaces very smoothly and very true. The first-named is used for smoothing simply, the second for both purposes. The wood scrape of the cabinet-maker effects a slight reduction in the surface of a cross-grained and curly piece of hard wood, veneer or otherwise, without tearing up the cross and curly grain as the plane would do. Having no penetrative power, it manifests no tendency to follow the grain and tear it out. Hence it can be used in all directions of the grain with equal effect. The metal scrape in like manner removes the marks of the cutting tools and of the files by which material has been removed in bulk, and also permits a localisation of effort when absolute accuracy of surface is desired. The point of a scrape can be made to operate over an exceedingly small area, whereas the action of a file or a cutting tool cannot be so concentrated. The most accurate results possible in hand work, therefore, are produced by scraping; all the metal slides and take-up strips in machine tools, engines and other mechanisms, and in surface plates and straightedges being so treated in the best work. Each of these tools, therefore, the wood scrape and the metal scrape, though so extremely simple in themselves, are as absolutely indispensable as the more pretentious cutting tools which we have already enumerated. They also figure largely in the kit of the ornamental turner working in hard wood, bone, and ivory.

Scrapes for Wood. Examples of wood scrapes are shown in **20**, comprising the inclusion of straight lines and of curves. They may be purchased, but cabinet-makers often cut them from old saw-blades. A couple of metal scrapes are shown in **21**, the first for flat surfaces, handled like a file; the second for concave bearing brasses, operating by the curved edges.

A group of scraping turning tools for wood, bone, and ivory is illustrated in **22**. A is the round nose, B the diamond point, C and D the right and left hand side tools. The under side, or bevelled side, of each of these is seen, the tools being turned over for use. Succeeding tools are of smaller size, E, F, and G being of curved shapes for various curves, H and J cranked tools for internal straights and curves, while K is a parting tool. Several modifications of these types are used in ornamental turning for producing the more intricate forms.

Scraping Tools for Metal. Tools which operate simply by scraping are employed largely by the metal-turner and machine hand for broad finishing of surfaces; they obliterate the minute ridges left by the regular cutting tools. And they are also profiling tools, producing convex, concave, and other sections the exact counterparts of the tool shapes. Some common forms of these finishing tools are shown in **23**. A is a plain, straight-nosed finishing tool; B and C, convex and concave tools, for finishing hollows and beads; D is a radius tool, for trimming the ends of work neatly to a curve. The circular tool, E, is used for large radii, the reduction of the shank permitting easy access to undercut curves; F is employed for inside work. The parting or cutting-off tool, G, is of narrow section. It is a type which tends to dig in, owing to the absence of side feed, and top rake is therefore not advisable. The spring tool H is not suitable for accurate work, but it produces a fine finish, and does not tend to dig in.

If the foregoing strict definition of scraping tools be adopted, they form an exceedingly numerous class. For to these belong not only the various scrapes pure and simple, but most of the milling cutters, the files, saws, and many of the cutters set in boring heads, some of the drills, the reamers, and rose bits—a very numerous family. But having stated these facts, we shall no longer

follow a strict classification, but consider them all as belonging to the great group of cutters. This will be more convenient, being more in harmony with the variations that occur in tools of the same name and with the results which they produce.

Milling Cutters. The employment of single, narrow-edged tools of the chisel type, described in the preceding article, for operating on broad surfaces would appear rather incongruous even to an observer who knew nothing about workshop practice. And it has, in fact, always been considered most unsatisfactory by engineers that a powerful machine often costing hundreds of pounds should be used to operate one little tool taking off a slice, say ⅛ in. wide. Many attempts have been made to remedy so anomalous a condition of things. But experience has proved that it is difficult to multiply single cutting tools on a machine unless the work is of a very simple and repetitive character. Hence, improvement has come in another way. Instead of attempting to multiply these tools, the device is adopted of arranging a number of cutting edges in a circular form, and of operating them in rotation. Instead of taking off a narrow shaving of considerable depth, a broad but shallow cut is taken. These tools are termed *milling cutters*. The conditions of operation are different in the two systems, but the final results are similar. The milling cutter is more economical, and is much better adapted for some classes of work than single-edged tools are.

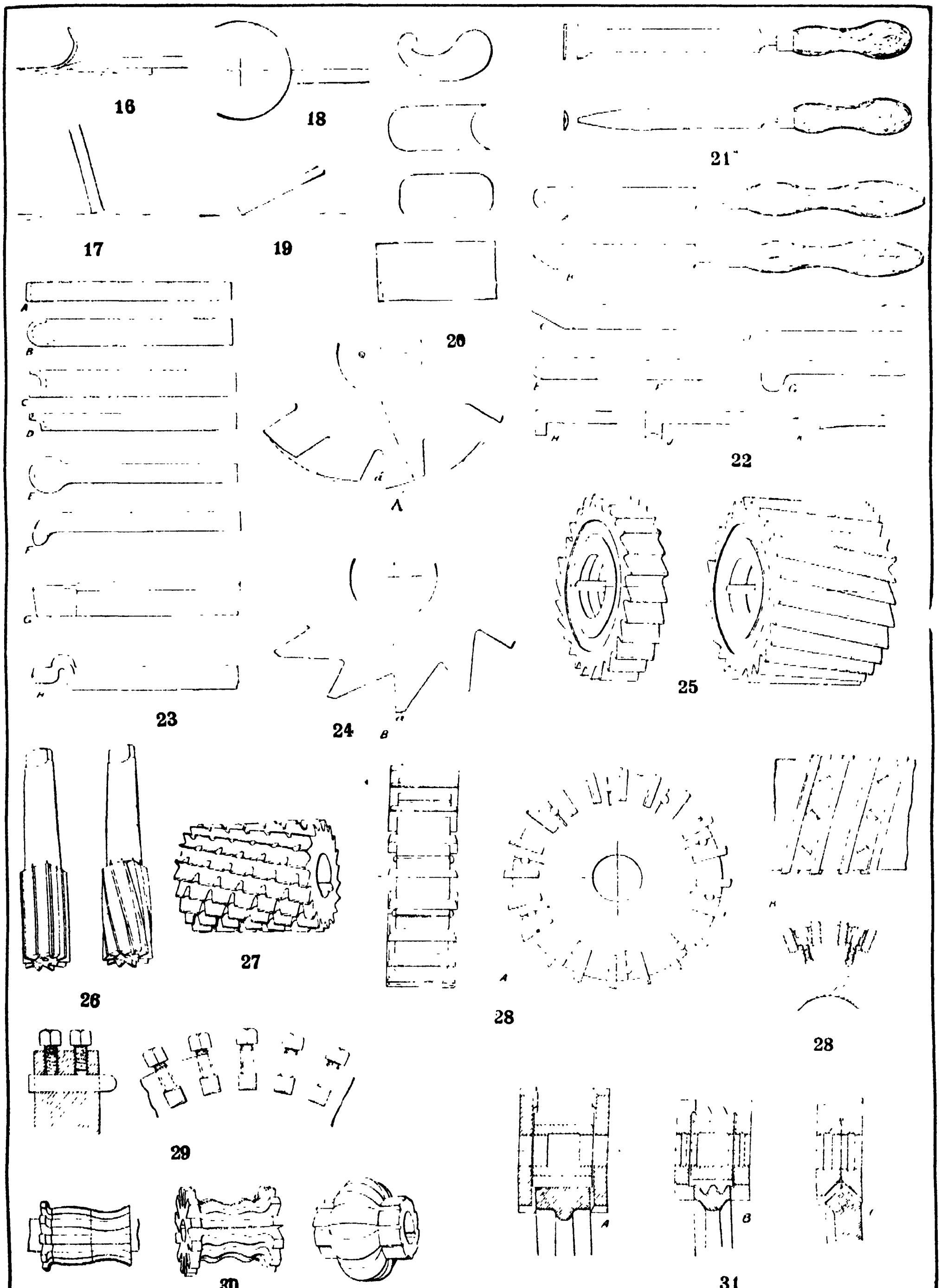
The milling cutters contain a large number of teeth arranged in circular form, each of which cuts in succession. The width may range from ⅛th in. to 24 in., or even more, so that surfaces of any reasonable breadth are finished without any movement or feed of the cutters transversely. But the teeth are not precisely like those of common tools. The front or top faces are nearly, or quite, normal to the surface of the work, so that the action is less that of true cutting than that of scraping. But what is lost in this way is more than gained by the multiplication of cutting edges and by the advantage of periods of rest intervening, due to each cutting edge revolving in air before taking a second cut, which gives it time to cool off.

Value of Milling Cutters. The cutting edges may be arranged round the periphery of a circle (*edge mills*), or on the face of a disc (*face mills*). They may occur in planes, or in any profiles, more or less irregular in contour. And one of the principal advantages derived from these cutters is due to the fact that they will produce irregular outlines, which cannot be nearly so well done by single-edged tools. They are immensely superior in this respect to any single tools, because the mill is made to the reverse form of the profile required, and thus finishes at once to shape. In form cutting also, outlines are produced which would be almost impossible of formation in any other machine. So immense is the development of milling practice that in many shops from 25 per cent. to 50 per cent. of the work formerly done on reciprocating machines of the planer, shaper, and slotter types is now executed by milling. In the cycle, sewing machine, and gun making industries, in which regular forms are so common, these cutters are used more extensively than in general engineering. The essential principle is the substitution of a multitude of cutting edges for one only. As the milling cutter revolves each edge operates in succession on the work which is passed under or alongside of it, with the result that a larger quantity is removed in a given time than would be possible with a single-edged tool, and generally the surface cut is much smoother. While, further, the width which can be covered by the edge of a single tool is always narrow, that which can be covered by a mill is almost unlimited. The only limit to width is the difficulty of the prevention of vibration in the mandrel or arbor which carries the milling cutter or cutters. A milling cutter can be driven twice or thrice as fast as a single cutting tool without getting hot.

The present growth of the milling cutters would never have been achieved but for the emery wheel. The early cutters had their temper drawn as often as the teeth became dull or damaged, to permit of refiling, after which rehardening followed. This, with its inevitable concomitant of distortion, rendered accurate results impossible. Actually, fine finishing was not attempted with the early cutters; they were used as roughing-out tools only or as preliminary to the subsequent corrections of the fitter or machinist. But when the emery wheel and its machines rendered the exact grinding of hardened cutters practicable, then the victory of the cutter became assured.

Relieving. Another event in the history of the cutter which contributed greatly to its success was the *backing-off* or *relieving* of the teeth in such a way that the sectional form of the teeth was not altered by any number of regrindings. The backed-off cutter has a centre eccentric in relation to the cutter centre from which the tooth curve is struck [**24**, A], so that whatever shape the tooth may present in profile is continued back over the width of the edge. Grinding, therefore, on the face, *a*, does not alter the form which will be milled, but only thins the tooth, and renders it weaker. The ordinary cutter [**24**, B] has no permanent profile, but is ground on the edge, *a*. This may be done to a definite outline, but is not nearly so simple a matter as the sharpening of the backed-off mill. Another advantage of the latter is that the teeth are much stronger, and able to take heavier cuts. Material help was afforded to the backed-off cutters by the invention of the relieving lathe, in which the tool slide of the rest receives a definite reciprocating motion for each tooth that is brought round and presented to it. All the teeth on a cutter are thus backed off alike, and rapidly, and so the labour of filing the clearance by hand is saved. Filing, moreover, would be a most difficult method of producing the profile.

Variations in Design. The milling cutter has also grown with the machine until it has become a protean tool. It is made very



WOOD AND METAL WORKING TOOLS

16. Action of chisel **17.** Action of scrape **18.** Action of turner's scrape **19.** Action of metal-worker's scrape **20.** Scrapes for wood **21.** Scrapes for metal **22.** Scraping tools for turning wood, ivory, bone, etc. **23.** Scraping tools for turning metal **24.** Backed-off and ordinary milling cutters. **25.** Straight and spiral-toothed mills **26.** Straight and spiral-toothed end mills **27.** Staggered mill **28** Inserted-tooth mills **29.** Inserted-tooth face mill **30.** Form mills **31.** Built-up mills for circular milling

small and very large, with solid and with inserted teeth, suitable for finishing or for slogging. The staggered and the inserted teeth both have this end in view. On the other hand, the spiral arrangement of the teeth of mills has been a great factor in producing smoothness of cutting. There is no rule for this practice, which goes over a wide range, from a moderate twist to a very great amount, especially in some of the French mills. The shearing cut produced lessens chatter, and chatter has always been an evil to which milling cutters are peculiarly liable. Fig. **25** illustrates the difference between straight and spiral teeth, the one, a narrow cutter, being straight faced; the other, a wide one, having the teeth slanting. End mills [**26**] are also made straight and spiral. The staggered mills [**27**] are used chiefly for heavy roughing, the teeth being divided up into short sections by a spiral groove running around so that the chips break up into short pieces and so do not clog the action like long, stiff cuttings.

Inserted Teeth. The inserted-tooth cutters are made with the object of saving tool steel, and of giving facility for manufacture. One good method of fitting is that in **28** A, where the flat cutters are held in the cast-iron body by taper pins, which are driven in the sawn slots to open these out and jam the cutters on each side firmly. The cutters may be set straight faced, as shown at A, or on an angle, as at B, to give a shearing cut. Another device, also depending on wedge action, is that in **28** B. Here each pair of teeth is held by a strip wedge, jammed in with three or more set-screws. So long as the screws are tightened up, the cutters cannot move, They are frequently made with notches, so that a staggered effect is produced similarly to **27**, the notches in one cutter coming alternately to those in the next cutter.

A simpler method is followed in the large face or ending mills, which are made up to several feet in diameter, set-screws, one or more to each tooth, being used for fastening, as in **29**. Several dozen tool points may be held thus in a large disc.

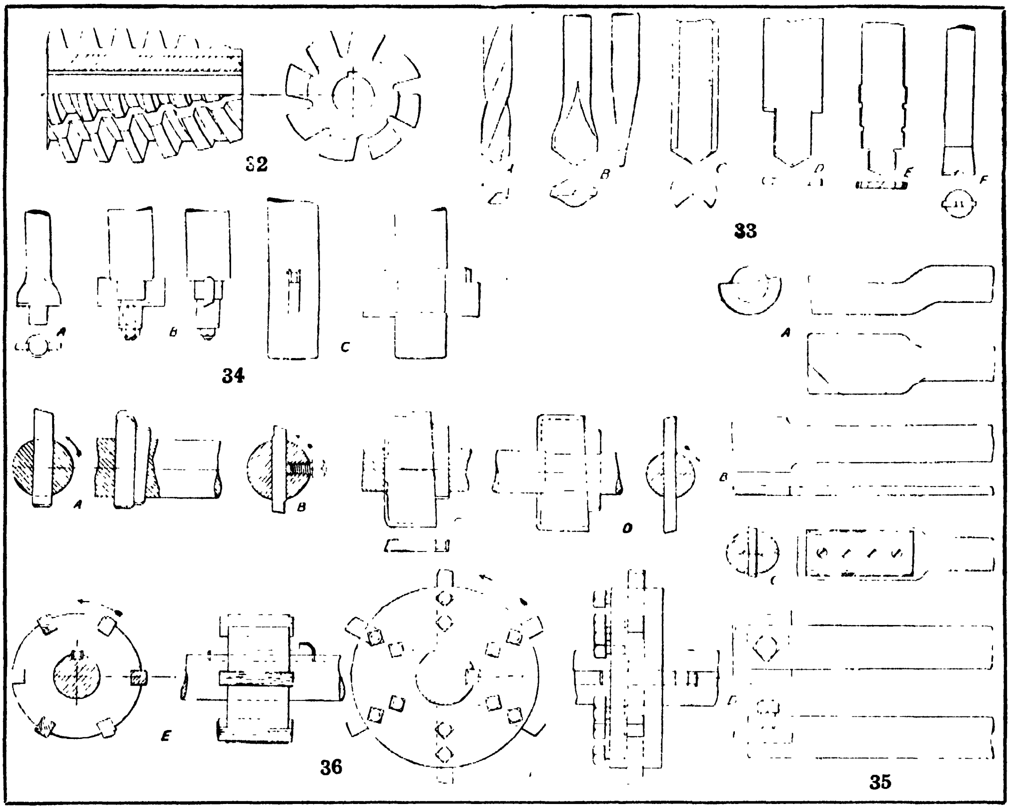
Form Mills. Form mills occur in innumerable shapes, including straight and curved portions, or in the latter alone. They are made in very intricate outlines, but as backing-off is done, the strength of teeth is ample, and the cutter remains in use for a long period. It is usually more convenient to build up difficult shapes from several separate cutters, stringing them together upon an arbor. A few examples of form mills are given in **30**.

Built-up Mills. In **31**, examples of built-up mills for circular milling are shown, the work revolving against the rotating cutter, which tools the edges and faces simultaneously in less time than they could be turned. A employs three cutters for milling a gear-wheel blank on the rim; B mills a rope-pulley with two grooves; while C shows two cutters tooling a bevel-wheel blank. There is hardly any limit to the profiles which can be thus treated, the number of cutters being increased if necessary. The wear of the side-cutters may be compensated for in A and B by placing washers between the three cutters and inserting fresh thinner ones when regrinding has reduced the height of teeth of the outer cutters.

A profile cutter of a different style is that shown in **32**, a worm hob on the Reinecker system. It is turned up to the form of a triple threaded worm, grooved and backed off. The tapered form is produced in order to hob the wheel in successive stages to the full depth.

Drills and Allied Tools. In drills we see that precisely the same principles hold good among these as among other tools, and that they afford examples of tools some of which act by scraping only, others by true cutting. The best form of drill is the twist type [**33**, A]. Although a twist is imparted to the body of the drill in order to allow of the free passage of the chips upwards without choking, yet it also fulfils the very important function of imparting front rake to the cutting edge, an advantage which is absent from the common flat type [**33**, B]. Since the cutting edge is ground transversely to the face of the twist, the angle which the twist makes with the vertical equals the amount of front rake, and is constant. Also the bottom of the drill is ground slightly backward, and this gives the angle of relief, or clearance. Thus, the exact conditions of a true cutting tool are fulfilled here. In the flat drills, however, there can not only be no front rake, but the reverse very often, rake being negative, the cutting face actually leaning over from the perpendicular [B], which leaning over is necessary in order to keep the point or apex of the cutting edges as thin as possible. But the angle of relief is present, being imparted by the grinding backwards of the edges. In the lip drills, front top rake is imparted sometimes by turning up the lips, or by filling grooves in front of the cutting edges. These, however, have the disadvantage of not maintaining their edges so long as the flat drills; the grooves soon disappear by sharpening.

Efficiency of Drills. Badly formed though the flat drill is theoretically, yet as a drilling instrument it is very efficient. For it is a case of two equal and opposite forces—that is, of course, supposing that the drill is ground symmetrically—which balance each other, and maintain the tool in equilibrium. Moreover, the downward pressure of the tool in a conical-ended hole tends to preserve its concentricity, allows any force to be impressed upon it within the limits of the strength of the drill, and nullifies the very bad shape of the drill-point, which, passing straight across from face to face, can never actually cut, but only scrape and crush the metal. The slight amount of parallelism of the shank above the cutting edge also helps materially in the true guidance of the drill. But in the twist-drill we have almost absolute perfection—parallelism, front and back rake, and a clear passage for the chips, so that these drills must eventually drive all others out of the shops for general work. The outputs of twist-drills are greatly increased by an abundant supply of lubricant, which is conveyed to the point either through holes in the body of the drill, or through



METAL-WORKING TOOLS

32. Worm hob **33.** Drills **34.** Counterbores **35.** Boring tools **36.** Boring bars and heads

tubes lying in grooves along the body. A pump must be used to give sufficient pressure to force the lubricant in and wash out the chips.

The straight-fluted drill [33, C] does not possess top rake, and is therefore of more value for brass than for the fibrous metals. It has the advantage that on breaking through the metal at the end of the hole it does not tend to twist and run through, as twist-drills do. Two modifications of the flat drill are shown at D and E, used chiefly for brasswork, and generally in turret lathes. D drills a hole of two diameters, with a shoulder, being followed by a reamer when necessary, and E produces two diameters, the body being serrated to break up the chips. F is a slot drill, used for producing longitudinal slots, such as cottar ways and key ways, either the work or the tool travelling.

Counterbores. Counterbores resemble drills in their action, but are used for enlarging the end of a hole already drilled, to receive the head of a pin or bolt or screw. A plain forged form [34,A] has lips projecting from the shank, so that they cut an annulus of metal, the pin below keeping the tool central. The style at B permits of readily changing cutters and guides. The cutter is held by the central set-screw pressing with its point, while the guide below the cutter takes the form of a bush held on by the nut and washer. Different sized bushes may be substituted to suit the drilled holes to be counterbored. A simple type for large holes is that at C, the cutter being held in its bar by a wedge, so that it is readily removable.

Boring Tools. There is also a large group of tools used in boring. First, there is the D-bit, or half-round bit [35, A], which is capable of boring holes many feet deep, provided efficient lubrication be provided. It is used in the lathe and fed into its work by the loose poppet, or by the slide rest. It is a cutting tool, having slight top rake provided by the upstanding corner lip. Flat bits form a goodly proportion of the boring tools used in the lathe for the holes in pulleys, wheels, bearings, etc. No top rake is, of course, present. Fig. 35, B, is a style cutting on the front and along the edges; it is fed up by the poppet, and steadied close to the work by a rest having a flat slot in it. A device often adopted is to screw blocks of hard wood to each side of the bit as at C, with the object of steadying it in the hole and preventing chatter. This is the chief trouble with these flat bits, want of guidance, so that unless care be taken they will follow the run of the cored hole, and result in untrue holes. In order to save tool steel, bits are frequently pinched in the end of a bar [35, D] with a set screw.

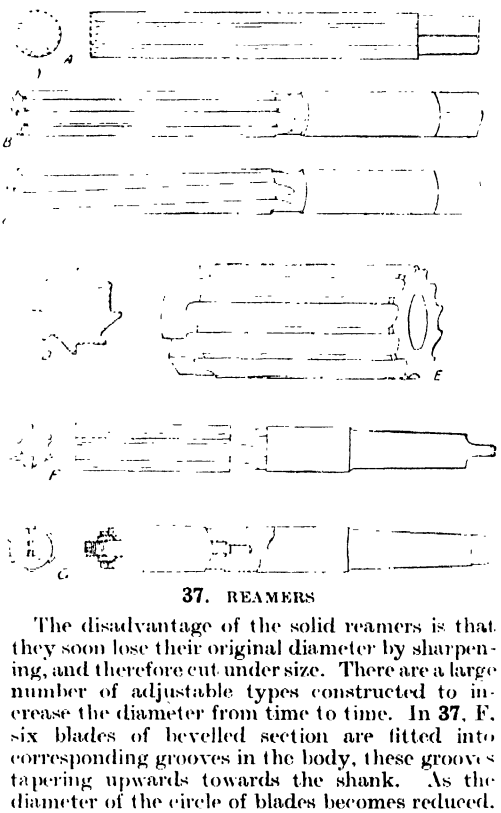
Boring Bars and Heads. Boring bars, which are revolved between the centres of a lathe, or in the boring machine, carry either a single cutter or a ring of cutters. For small holes the single cutter is very suitable ; in fact, there is often no room to get more than one cutter to work. Fig. 36, A, is a square cutter held in the bar with a wedge. The cutter has no front rake ; B is a double-ended cutter fastened with a set screw ; C shows a double-ended flat cutter wedged in ; it cuts on front edges, and along the sides also ; D is a cutter secured centrally by cutting out a notch in the front, so that the two shoulders fit over the mouth of the slot in the bar, and prevent risk of lateral movement.

The boring head with cutters, used under so many modifications, consists usually of an assemblage of scraping tools, notwithstanding that true cutting tools are often employed in the same head. The advantage of the arrangement consists in this, that the cutting forces are balanced all around the bar, and the latter is therefore less liable to spring and is better able to bore a true hole ; also, that in direct proportion to the number of cutters employed can the traverse feed be increased, because the duty is divided between all the cutters. Thus, a block with six cutters can be fed at six times the speed of a single tool. Fig. 36, E, shows a block with three cutters held in with wedges. There are also three hardwood strips driven into grooves alternating with the cutters, the object being to steady the head in the bore. Another style of head, shown at F, has six square cutters, each gripped with a couple of set screws. A good many heads of this style are built, with an increased number of cutters in the larger sizes.

Reamers. These are generally scraping tools, but some have a slight amount of front rake. A rose reamer (or broach) is seen in **37**, A, and examples of fluted reamers at B, C, D, and E. These are of different design, but not different in their functions. They are used for enlarging holes to a finished dimension very slightly in excess of that left by a drill, and with a degree of accuracy usually unattainable with a drill. Also, even supposing the drill to be in good condition and the holes true individually, yet when two or more such holes have to come in juxtaposition to each other to take a single bolt or pin, there is often a want of strict alignment. Then the holes, being all reamered out at one operation, are true.

Fluted Reamers. The fluted reamers are either straight or spirally fluted, the two forms being shown at B and C. The latter has a smoother action. A device used in some cases is to form a fine thread for a short distance on the end of a reamer, so that it is drawn into the hole without excessive pushing effort on the part of the operator. The form of serrations usually made in reamers is shown in section at D, the front of the tooth pointing radially to the centre, while the back is cleared off in a slight curve. Alternatively a flat clearance may be formed. The edges of the teeth are either backed off with a flat, or with a curve, like relieved milling cutters, the latter form being rather stronger.

Shell Reamers. The hollow or shell reamers are made to fit on an arbor, a slot at the back of the reamer being driven by a cottar in the arbor. The flutes are either straight, as at E, or spiral. These shell reamers are of larger size than the solid types ; by mounting one or more on a long arbor, holes in line may be reamered out in alignment. A device which is followed by some makers is to make an odd number of flutes, and sometimes to space them unequally, so that the teeth are less likely to follow the course of an irregular hole.



37. REAMERS

The disadvantage of the solid reamers is that they soon lose their original diameter by sharpening, and therefore cut under size. There are a large number of adjustable types constructed to increase the diameter from time to time. In **37**, F, six blades of bevelled section are fitted into corresponding grooves in the body, these grooves tapering upwards towards the shank. As the diameter of the circle of blades becomes reduced, they are hammered farther into the grooves, thus increasing the diameter. When the limit of driving up is reached, a new set of blades is provided. Another method of fitting, shown in **37**, G, involves the use of a central tapered plug, which, when screwed inwards, forces the blades out, the lock nut at the end being first slackened to permit of the adjustment being made. This principle of using a taper to expand the blades is followed in several other designs of adjustable reamers.

Continued

Continued from page 4209

THE ROYAL NAVY

Conditions of Entrance and Service in the British Navy. Seamen and Artificers. Pay and Promotion. The Royal Marines

By C. DUNCAN CROSS

By its glorious traditions and the opportunities it offers for seeing the world, the Royal Navy appeals alike to the patriotic and the adventurous instincts of a boy. The modern tendency towards comfort has shorn the Service of its hardship, and the opportunities for advancement make an appeal to a lad who loves the sea and is willing to work hard at an interesting career for a living wage and a comfortable pension. As the science of war advances so does the standard of intelligence, and to-day it is necessary for a Navy man not only to be strong, but also to have brains to direct his energy aright. For the past 50 years the class of sailor has been improving, till to-day he ranks high among the skilled workers.

So high is the standard of efficiency required of petty officers that the barrier between the officer and man is no longer insurmountable, and to-day a youth who enters the Navy at the age of 16 may well hope to reach a commission before he retires from the Service. Even should the hope fail to materialise, his training has been such that there is an excellent prospect of obtaining civil employment ashore.

How to Join the Navy. Application may be made to the station officer of any coastguard station; to the Royal Marine Recruiting staff officer at Belfast, Birmingham, Bristol, Exeter, Glasgow, Liverpool, London, Manchester, Nottingham, Southampton, or York; to the Commodore of the Royal Naval Barracks at Portsmouth, Devonport, Chatham, and Sheerness, and the Naval Recruiting officers attached to those ports; or at one of the outlying stations which are scattered through the large towns of the British Isles.

The standards vary from time to time, but it may generally be understood that a youth or man who possesses the qualifications set forth in the table may expect to be admitted as far as his physical requirements go. It should be observed with regard to chest measurement that the examining officer notes particularly the difference between the size of the expanded and contracted chest. This difference should not be less than two inches.

In reply to an application, a form is supplied to the candidate which he is required to fill up, and if his replies be satisfactory, he is provisionally examined. He is then sent to one of the depots for a final medical examination, the trade test (if the candidate desire to enter one of the trade openings), and a simple educational examination. If he fails to pass, his fare is paid home.

The physical standards required of candidates for the Royal Navy are as in the following table:

Age.	Height without Shoes.	Mean Chest Measurement.	
Boys:			
15¾ and under 16	5 ft. 2 in.	32½ in.	
16 ,, ,, 16½	5 ,, 2½ ,,	33 ,,	
16½ ,, ,, 16¾	5 ,, 3 ,,	33½ ,,	
Youths:			
16¾ and under 17	5 ft. 2½ in.	33 in.	
17 ,, ,, 17½	5 ,, 3 ,,	33½ ,,	
17½ ,, ,, 18	5 ,, 3½ ,,	34 ,,	
Seamen, Special Service:			
18 and under 19	5 ft. 3 in.	34 in.	If 5 ft. 5 in., 34½ in.
19 ,, ,, 20	5 ,, 4 ,,	34½ ,,	Or over, 35 ,,
20 ,, ,, 21	5 ,, 5 ,,	35 ,,	If 5 ft. 7 in., 35½ ,,
*Over 21	5 ,, 5 ,,	35½ ,,	Or over, 36 ,,
Stokers, Continuous or Special Service:			
18 and under 19	5 ft. 3 in.	34½ in.	If 5 ft. 5 in., 35 in.
19 ,, ,, 20	5 ,, 3 ,,	35 ,,	Or over, 35½ ,,
20 ,, ,, 21	5 ,, 3 ,,	35½ ,,	If 5 ft. 7 in., 36 ,,
Over 21	5 ,, 3 ,,	36 ,,	Or over, 36½ in.
Domestics:			
16 and under 18	5 ft. 0 in.	32½ in.	
Over 18	5 ,, 3 ,,	33½ ,,	
Sick-berth Attendants:			
18 and under 19	5 ft. 4 in.	34 in.	If 5 ft. 6 in., 35 in.
19 ,, ,, 20	5 ,, 4 ,,	34½ ,,	Or over, 35 ,,
20 ,, ,, 22	5 ,, 4 ,,	35 ,,	,, ,, 35½ ,,
		Of any age between 5 ft. 5 in., and 5 ft. 6 in., 34½ in.	
Engine-room Artificers, Electricians, Armourers, Blacksmiths, Carpenters, Coopers, Plumbers, and Cooks' Mates:			
18 and under 20	5 ft. 3 in.	34 in.	
20 ,, ,, 22	5 ,, 4 ,,	34½ ,,	
22 ,, ,, 23	5 ,, 4 ,,	35 ,,	
Over 23	5 ,, 4 ,,	35½ ,,	
Ship's Stewards or Writers:	No fixed physical standard.		

* With Admiralty authority up to 25.

NOTE. These standards are liable to alteration according to the supply of and demand for recruits.

Special Service. There are two varieties of service—continuous and special. A Special Service man enters between the ages of 18 and 25, agreeing to serve for the first five years with the Fleet, and for the remaining seven years in the Reserve. Providing he reaches the rating of able seaman, he may earn one good conduct badge at the end of his first three years' service. This bears 7d. a week extra pay. If the man enters the Navy from the Mercantile Marine, he may even earn this badge at the end of twelve months. An additional 7d. a week may be earned by those who qualify as *trained men.* On transfer to the Reserve, with a retainer of 6d. a day, the man is liable to one week's training every year, or a fortnight every other year. In case of national emergency he is, of course, obliged to join the Fleet. If, after his 12 years' service is complete, the reservist elects to continue to re-enrol for successive periods of five years, he will receive a gratuity of £50 when discharged on completing 20 years' combined service in Fleet and Reserve; but no man will receive the gratuity or be released from liability for active

service until he reaches the age of '40 years. A special Service man has, be it observed, no chance of rising to warrant officer rank.

Stokers may enter the Navy in the Special Service class in much the same fashion as seamen. They must complete five years in active service and seven in the Reserve. Good conduct badges can be won in the same way as we have outlined above, and the gratuity on completing 20 years' combined service is the same. Special Service stokers do not, as a rule, rise above the rank of leading stoker, and it is hardly possible to rise even so far in the five years.

Generally, therefore, it may be said that in the Special Service there is no great prospect of a career. It is, however, an avenue for the men of the Mercantile Marine. They have five years' training, which is most valuable on returning to their civil occupation, and it secures them a retaining fee to add to their wages.

Continuous Service. Men of all ratings sign on for 12 years, at the end of which time they may re-engage for another 10 years to complete their service for a pension. At the end of 22 years' service they may retire with a pension, or they may be allowed in special cases, if their conduct has been all that could be desired, and if they have progressed satisfactorily, to serve until the age of 50, with an increase to their pension for every year's further service as petty officer. It is a condition with men and boys of the seaman or stoker class enlisted after March, 1901, that to qualify for the long-service pension they must belong to the Royal Fleet Reserve up to the age of 50.

Men disabled or invalided out of the Service are dealt with fairly generously on a sliding scale by pension or gratuity, according to the nature of their disablement and the circumstances in which they are placed. Men disabled in the execution of their duty are awarded life pensions, irrespective of the length of their services. Furthermore, a grant of £22,000 a year is made by Greenwich Hospital for the assistance of seamen or Marines who have no naval pension or whose pension is small. Pensions to widows, etc., are another feature of the benevolent side of the Service. Another most excellent institution is the Greenwich Hospital School, where 1,000 sons of seamen and Marines are educated and maintained free of cost. In addition, 100 boys and 150 girls are maintained at various homes.

All men, whether for continuous or special service, receive a grant towards the cost of their outfit and bedding. In addition to their pay they receive free rations on a scale greatly improved in recent years. Out of this, by careful management, it is possible to effect "savings," which are credited to the man, and go to buy luxuries.

Boys. A boy must be of good character, must produce a birth certificate, or a declaration made by his parents before a magistrate that he is of the proper age, and the written consent of parent or guardian to his entering the Navy and to his agreeing to serve until he has completed 12 years continuous service from the age of 18. He must be able to read and write a passage from a Standard IV. reading-book, to write a similar passage from dictation, and to have a fair knowledge of the first four rules of arithmetic.

On acceptance, the boy is sent to a harbour training ship, and is credited with £10, with which he must purchase the kit laid down in the regulations, the sum remaining over being placed to his credit for future expenses, for he will in future have to depend almost entirely on himself for new clothes.

After six or twelve months' training on board the harbour ship the boy is drafted to a sea-going training ship to gain a knowledge of seamanship and gunnery.

Youths. Youths entering between 16 and 17 years of age must have the consent of parent or guardian and join the training ship direct, without harbour service. They are rated as second-class boys for the first three months. Later, boys and youths are rated as first-class boys until they are 18 years of age. Before attaining this rating, be it observed, they must learn to swim.

The cruise ended, and the boys having reached the age of 18, they are sent to take their place in the ranks of the Navy as ordinary seamen. No examination is required for this rating, and it is only now that the ambitious young man has a

PAY OF WARRANT OFFICERS, PETTY OFFICERS, AND MEN.

	Per Annum. £ s. d.	Per Day. £ s. d.	
Chief Gunner, Boatswain, or Carpenter ..	182 10 0 to 219 0 0	0 10 0 to 0 12 0	With Allowances for Special Duties and Certificates G. or T.G.
Gunner, Boatswain, or Carpenter ..	100 7 6 to 164 5 0	0 5 6 to 0 9 0	
Chief Artificer Engineer ..	209 17 6 to 246 7 6	0 11 6 to 0 13 6	
Artificer Engineer ..	155 2 6 to 191 12 6	0 8 6 to 1 10 6	

	Per Day. s. d.		s. d.
Master at Arms	4 0	to	6 0
Chief Engine-room Artificer ..	7 0	to	7 6
Chief Electrician	7 0	to	7 6
Chief Petty Officer	2 8	to	3 2
Chief Yeoman of Signals ..	2 11	to	3 5
Engine-room Artificers	5 6	to	6 6
Mechanician	3 0	to	5 0
Electrician	5 6	to	6 6
Chief Stoker	3 0	to	5 0
First Class Petty Officer	2 2	to	2 5
Yeoman of Signals	2 5	to	2 8
Acting Stoker Petty Officer ..	2 10		
Leading Stoker	2 3	to	2 6
Second Petty Officer	2 0		

	Per Day. s. d.		Per Day. s. d.
Leading Shipwright	4 3	Ordinary Seaman ..	1 3
Leading Seaman ..	1 9	Signal Boy	0 7
Leading Signalman	2 0	Boy, 1st Class	0 7
Able Seaman ..	1 7	,, 2nd Class	0 6
Qualified Signalman	1 10	Boy Artificer	0 6 to 0 9
Stoker	2 0		
,, 2nd Class ..	1 8		

ROYAL MARINES.

	Per Day. s. d.		Per Day. s. d.
Colour-Sergt., R.M.A. ..	4 2	L.I. ..	3 5
Sergeant, R.M.A. ..	3 7	L.I. ..	2 9
Corporal, R.M.A. ..	2 11	L.I. ..	2 1
Bombardier, R.M.A. ..	2 8		
Gunner, R.M.A.	1 7	Private, L.I.	1 4

chance of showing what he is worth. He goes to sea in one of his Majesty's warships, and he has the opportunity of learning from his officers and the instructors something practical of gunnery, seamanship, and sufficient engineering practice to pass his examination for able seaman.

Examination for Able Seaman. This examination is of the most practical nature imaginable, and consists of the following tests.

A fair knowledge of steering a ship, heaving the lead, rowing, knotting and splicing (hemp and wire rope), and general duties of seamanship; gunnery, torpedo, and field training, which he has learnt during his novitiate. He must be able to use simple engineers' tools and do ordinary stokehold work, such as sweeping tubes, cleaning boilers, etc. He must also have a knowledge of bunker work, firing, and watch keeping, all of which he will have learnt during his 30 days' course on board ship, during which time he is attached to the engine-room staff and is under the orders of the engineer. Furthermore, he must be able to make and read slowly a signal in semaphore, and understand the use of the flags used in flag signalling.

As able seaman he will turn his mind to gunnery, and will receive instruction in gun-laying, sight-setting, etc., from the gunnery lieutenant and the gunner, and in torpedo work, so as to gain the badges of seaman gun-layer, or seaman torpedo man, or turret gun-layer, etc., each distinction earning him a badge, and each badge carrying with it increase of pay, varying according to the qualification.

He will bear in mind also the good conduct badge which he will be permitted to wear after three years' service as seaman, with a "very good" character from his captain. These badges, awarded at the end of 3, 8, and 13 years' service, carry with them extra pay at the rate of 1d. per day each.

Leading Seaman. Leading seaman is the next step in the sailor's career, which means that he is a good helmsman and leadsman, able to assist in sailmaking and repairing; a practical rigger. He must have a thorough knowledge of the practical side of gunnery; he must be able to make and read semaphore signals, and he must know the use and colours of such flags and pennants as will enable him to look out a signal in the boat's signal book. His examination is carried out in a sea-going ship, and qualifies him for promotion to second-class petty officer.

Petty Officer. As petty officer the man must, to a certain extent, remodel his existence. He is now in authority; he is directly responsible to his superiors that discipline is maintained, and that the men under his charge do their duty efficiently. By this time he will have made up his mind whether he prefers the duties of mere seamanship and the working of a ship, or whether the guns attract him more. In the first case his goal will be that of boatswain, and in the latter he will aspire to the position of gunner.

It is of the highest importance nowadays that men should take the earliest opportunity of qualifying in gunnery and torpedo work, for more and more attention is being paid to these branches of a seaman's education, and it may quite easily happen that his promotion will be very seriously retarded by the lack of a certificate.

From 2nd class petty officer the man is promoted to 1st class petty officer, and lastly he reaches the rating of chief petty officer or warrant rank (gunner or boatswain), when he drops the bluejacket's characteristic garb for the blue cloth coat and peaked cap.

Chief Petty Officer. Candidates for chief petty officer are not put on the roster until they have five years' service, with a very good character. Then their names are put down for promotion, and in due course they are selected by seniority, tempered by selection, on the reports of service and attainments. Since a warrant officer or a chief petty officer comes into close contact with the officers of the ship, it is most desirable that he should have taken every possible step to improve his education and his manners in the time of waiting by the assistance of the instructor and by private study.

Chief petty officer is the highest position reached by the majority of seamen. The man for whom this article is written, however, will aspire to climb yet one step higher to the commissioned rank of lieutenant. For this rank it is essential that his education should be excellent, for he may have to live in the ward-room with college-trained officers, and this point is taken into consideration in selecting men for commissions. It should be noted that commissions are given only to chief petty officers under 44 years of age, and that warrant officers must reach that rank before they are 35.

Promotion in the Navy. To give some idea of the rate of promotion in the Navy, it may be said that a smart young man with a fair education might hope, with luck and diligence, to reach the rank of second or first-class petty officer by the time he is 24, and to become chief petty officer at 28 or 30 years of age. Warrant rank would come in about the same time.

It should not be forgotten that for chief petty officers and warrant officers there are many good shore billets in the shape of instructorships at the colleges, at torpedo and gunnery schools, which not only carry with them a handsome increase of pay, but provide a most comfortable home for a man who has, perhaps, tired of the perpetual change of quarters which the exigencies of naval service involve. These go, of course, to men who are favourably reported to headquarters as being energetic, trustworthy, and who, by their application to the theoretical side of their work, have fitted themselves for the posts.

Engine-room Staff. Boys may be entered as boy artificers between the ages of 15 and 16 after passing the usual medical examination and an educational test of ability to read and write. They agree to serve for 12 years' continuous service from the age of 18.

On entry the boy artificer is placed on the ship's books for training at one of the home ports, and for the first four years is learning his trade as a workman under an instructor; is instructed

in steam and in general engineering subjects by an engineer instructor, and in general knowledge by a schoolmaster. His duty in life will be the care and repair of engines as compared with the stoker class, whose business is to drive them. After the four years' course, and a final examination in the subjects studied, he is classed as engine-room artificer 5th rate. He goes to sea for a year, and if he can pass the examination outlined below he is rated as acting engine-room artificer 4th class. It is possible for a practical engineer between 21 and 28 years of age to enter direct if he is able to pass the examination, which is as follows: A knowledge of the first four rules of arithmetic; ability to read and write well enough to record the working of engines and boilers; a general acquaintance with the names, uses of parts of marine engines; ability to run engines and to effect the ordinary repairs of an engine-room. Candidates who hold a Board of Trade engineer's certificate, 1st or 2nd class, are excused this examination. After one year's service as acting engine-room artificer 4th class, the man, on obtaining a certificate from the captain that he is capable of taking charge of a watch in the stokehold, and that he is an efficient workman worthy of confirmation in his rank, becomes a 4th class artificer.

After three years' service above the rank of 5th class artificer, he passes to 3rd class artificer; in another seven years to 2nd class artificer, and, if he engages for another 10 years, to engine-room artificer 1st class. Above this lies chief engine-room artificer 2nd class, for which he must pass an examination in arithmetic up to vulgar and decimal fractions, and show his practical knowledge by being able, for example, to estimate bunker capacity or a cylindrical oil tank's contents. His knowledge of engineering must be wide and practical. He must know the best methods of prevention and cure of ordinary engine and boiler room casualties; must understand the management of boilers generally, and the running and use of valves; have a good knowledge of indicator diagrams and the calculation of horse-power; understand the adjustment of bearings and the fitting of brasses.

Six years in this rating qualifies him for chief engine-room artificer 1st class. Chief engine-room artificers of 29 years of age are eligible for advancement to warrant rank on passing the examination for artificer engineer and receive a gratuity of £25. These, again, may pass to chief artificer engineers, from whom, by selection, are chosen a few engineer lieutenants.

Stokers. The men who tend the boilers are in a far better position to-day than they were formerly. "Once a stoker always a stoker" used to be the saying; but now, by good conduct and willingness to work at the theoretical side of his trade, the stoker can rise to be chief petty officer, and even attain warrant rank, though few stokers expect the latter. An able-bodied man of good character and physical development, without previous experience, may enter as 2nd class stoker. After a period of instruction in his duties and in rifle, pistol, and cutlass drill (for a stoker must know how to fight nowadays), he is promoted to stoker on completing a year's service.

After four years' service comes a test examination based on the "Steam Manual" (Articles 351 and 509), and that being satisfactorily passed, he becomes leading stoker, and is rated as a 2nd class petty officer. After serving in this capacity he is eligible for advancement to acting stoker petty officer. It will now be necessary for him to work hard at his education if he wishes to rise further. He must attend a torpedo course to give him a knowledge of the engines and general working of these weapons, and after having served ten years in stoker ratings he may be promoted to chief stoker, which ranks as chief petty officer. The examination is the same as for leading stoker, but in addition he must have a general working knowledge of the parts and uses of engines and boilers. Provided they have at least five years to serve, chief and leading stokers who qualify are eligible to be rated as mechanicians, rising to warrant mechanician and chief warrant mechanician when they take charge of engines.

Signalmen. Signal boys are selected from the smartest of the 2nd class boys, or, if vacancies occur, from among the 1st class boys. Occasionally they are entered direct from Greenwich School. They are given an elementary signal course lasting some three months, and are taught the elements side by side with their instruction in seamanship. The work requires keen eyesight and a lively intelligence, for a signalman is one of the most responsible men in the ship.

The next step, that to signalman, is reached when the boy is over 18. The aspirant by that time must have gained a working knowledge of day and night signals. For this and the higher ratings men are not obliged to qualify in the same fashion as an A.B., but are exercised in gunnery and musketry. For the rating of qualified signalman is necessary a good working knowledge of day, night, fog, gun, and sound signals as applied to fleets, ships and boats, as is a proficiency in the use of the Morse code, semaphore, and flash signals.

After a sufficient experience as qualified signalman a man is advanced to leading signalman, when he must be able to undertake the duties of a signal petty officer, and must understand the regulations for prevention of collisions at sea. Every three years signalmen are obliged to go to one of the signal schools to requalify for their rating, so that they may not lag behind the times. Good men with sufficient experience are then promoted to second yeoman of signals. Yeoman of signals and chief yeoman are the next steps in the signalman's career, the appointments being made by seniority, tempered always by selection of the best workers and the steadiest men.

Naval Craftsmen. A few boys between 14 and 16 years of age are eligible for service as boy shipwrights, and a few boys between the ages of 15 and 16 may be entered as boy

coopers. They have to pass the Civil Service examination laid down for dockyard apprentices, and agree to serve for 12 years after the apprenticeship, and are instructed in the yard until the age of 18, when they go to sea for training if they are found to be fit for the rating of cooper's crew or carpenter's crew.

Among the skilled tradesmen entered for service ashore and afloat are the electrician, the carpenter, and the shipwright, the armourer, blacksmith, and the cooper.

Young men of good character between the ages of 18 and 28 who are sufficiently good carpenters to do panelling, dovetailing, and sash-making, may join with the prospect of rising to leading carpenter's crew.

Coopers who can pass a trade examination in making a bucket, also armourers, plumbers, and cooks, with a knowledge of their respective trades, can all join the Navy with the prospect of rising to chief petty officer in due course.

Electricians. The electrician is another of the skilled tradesmen who are always welcome in the Navy. He must be between the ages of 21 and 28, and must have had three years' practical experience as fitter and turner. Men are preferred who have some knowledge of electricity or who have gained their experience in electrical shops. The candidate must pass an educational examination equivalent to school Standard VI., he must know arithmetic up to vulgar and decimal fractions, and be good at dictation and reading. The practical part of the examination consists in relining and readjusting metal bearings; metal turning and screw cutting on a lathe; and repairs to electrical apparatus and instruments.

As acting electrician, he enters the torpedo school and goes through a course of instruction, at the expiration of which he has to pass a further examination in repairing and fitting electric motors and all electrical instruments required in the Service. He must have gained a good knowledge of the construction and repair of Whitehead torpedoes, and he must understand the intricacies of electric lighting and wireless telegraphy. After his year's probation as acting electrician 4th class, he is advanced to 3rd class; in another six years to 2nd class, and in a further five years to 1st class electrician, provided he has re-engaged to complete his time for a pension. The rating of chief electrician, 1st and 2nd class, lies at the end of the service after a thorough examination in every branch of the art.

Sick-berth Staff. A limited number of young men between the ages of 18 and 22 may join the Service as sick-berth attendants if they can produce evidence of very good character, and have an elementary education. Selected candidates are accepted on probation, and go through a course of training at Haslar Hospital. They rise from sick-berth attendant through the grades of sick-berth steward, to chief sick-berth steward. There are a few shore berths open at Royal naval hospitals as ward masters, but promotion is not rapid, and unless the candidate has a special liking for the work, the position is rather trying.

The Royal Marines. The Royal Marines are soldiers with sea training and sailors capable of military duty; they are experts in artillery work, yet they can pull a boat as well as any seaman. Rather more than half are serving in detachments in sea-going ships, while the other half are at their various depots undergoing courses of infantry and artillery training. The advantages of the Service are change of scene and occupation, greater freedom of action than is enjoyed by soldiers, a wider field of training, and better pay. There are two branches—the Royal Marine Light Infantry (the Red Marines), and the Royal Marine Artillery (the Blue Marines).

Entrance Conditions. Growing lads from 17 years of age and men from 20 to 23 are eligible, provided they can pass the medical test and can read and write. On acceptance, they are forwarded to Eastney Barracks, Portsmouth, if for the Royal Marine Artillery, or the Depot, Deal, if for the Royal Marine Light Infantry. The Marine is obliged to engage for 12 years. Free kit and bedding are issued to every man.

The infantry recruit, after completing a course of infantry drill, swimming, gymnastics, and musketry, is drafted to one of the three great stations—Chatham, Portsmouth, or Plymouth—which becomes his home ashore, as is Eastney Barracks for the artilleryman.

Work of the Royal Marine. On completion of the above-mentioned instruction, the recruit undergoes a course of field training and heavy gun drill, and in about 15 months is considered a qualified man. He is then available for sea service, and, as soon as the exigencies of the Service allow, is drafted to one of his Majesty's ships. If his ship be serving in home waters, this period will be from one to two years, but if abroad, it will be probably three years before he sees his "home" again, when he will take his leave on full pay and come back to requalify in shore work. Promotion to the superior ranks is not so rapid as in Line regiments of the Army, but he may expect to be promoted to corporal within five years, to sergeant in 10 years, and to colour-sergeant in 16 years. There are also 29 warrant officers' positions open by selection and seniority to senior non-commissioned officers and 17 commissioned posts as quartermasters. The educational standards required of the various ranks are the same as those of the Army for an infantryman, promotion coming by the passing of these examinations and the sea service completed.

Bandsmen. Marine bandsmen join the service between the ages of 15 and 23. They must be able to read and write, and have some musical knowledge. They are sent for training to the Royal Naval School of Music for instruction, and at the age of 18, or when fully trained, they become available for service on a battleship or a cruiser. The pay ranges from 4s. 8d. a week for boys to 38s. 9½d. for the highest ranks, with an allowance of 1s. 2d. per week for instruments, and good conduct pay up to 3s. 6d. per week.

Continued

Group 23
APPLIED BOTANY
1
Following on NATURAL HISTORY from page 4089

TOBACCO

Varieties of Tobacco. Climate, Soil, and Fertilisers Needed. Cultivation and Harvesting. Methods of Curing. Grading. English and Irish Tobacco

THE natural order *Solanaceæ*, which yields the wholesome potato and tomato, and the poisonous belladonna and stramonium, furnishes also the tobacco plant. The greater part of the tobacco of commerce is obtained from one species, *Nicotiana tabacum*. There are many distinct varieties of this one species yielding Virginia, Cuban, Havanna, and Latakia tobacco. East Indian or Turkish tobacco is the product of *N. rustica*, which is also cultivated in Germany, Hungary, Egypt, and West Africa. It is a hardier species, and requires less time for maturity than *N. tabacum*. Shiraz or Persian tobacco is the product of *N. Persica*, Yana tobacco is furnished by *N. repanda*, and a very strong tobacco used in Chili is prepared from *N. angustifolia*.

N. tabacum grows from 2 ft. to 9 ft. high, and the stem bears at its summit a panicle of tubular pink flowers [1]. The wide-spreading leaves are ovate, oblong, or lanceolate in shape, and are attached to the stalk in a spiral manner. The leaves are clothed with long soft hairs, and have lateral veins proceeding from a thick midrib in straight lines at angles of 40 deg. to 75 deg., gently curving upwards only near the edge. *N. rustica* has greenish yellow flowers, and the leaves have longer stalks. The smell of the fresh plant is narcotic, and the taste bitter and nauseous. The characteristic odour of dried tobacco is developed during the curing process.

Varieties of Tobacco. There are some 64 varieties of tobacco grown in the United States. Each of the varieties is accredited with certain characteristics of leaf; but as to which variety should be grown in any particular country it is not possible to give any exact information, as so much depends on the soil and climate. Bright-yellow tobacco, such as is grown south of the James River in Virginia and in the famous Granville section of North Carolina, will not succeed on dark, rich, loamy, alluvial soil. This particular kind fetches the highest price among American tobaccos. The rich dark variety exported to England is grown on alluvial soils containing some sand and with clay subsoil.

Tobacco-growing is best suited for regions having a mean temperature of not less than 40° F., and which are not subject to autumn frosts. The comparatively dry climate of tropical countries is one in which tobacco reaches the highest state of perfection as regards flavour. The liberal amount of heat and light, together with sufficient moisture, is found to produce the most luxuriant development of the plant, and to increase largely the percentage of nicotine.

The quality of the soil in which tobacco is sown exerts an important influence on the texture of the leaf, and on the colour and burning qualities. Tobacco grown on very rich dark soils burns badly, whereas that grown on sandy soil burns well. Chocolate and sandy soils are preferred on account of the better flavour and aroma of the crop both for cigar and pipe tobacco. Colonel Everard, in the Irish experimental tobacco growing, found that a rather heavy clay loam, with a clay subsoil in good manurial condition, produced the best results, the tobacco growing well, and curing out a good colour with plenty of body and elasticity. Tobacco will not thrive except on a well-drained soil; a retentive clay subsoil, therefore, is to be avoided. The soil should be well ploughed and harrowed until it is well pulverised before sowing.

The Necessary Fertilisers. Manures for tobacco crop must not contain chlorides, as chlorides in the tobacco leaf adversely affect the burning qualities. Sulphate of potash in excess has a similar injurious effect. Large quantities of phosphoric acid give a dark-coloured ash to the tobacco, and excess of nitrogen in the soil makes a coarse thick leaf, unsuited for wrapper types of tobacco but suitable for manufacturing and export kinds. To produce cigar wrapper leaf and bright yellow leaf only moderate quantities of stable manure may be used, or the leaf will be thick and coarse. Cotton-seed meal is a good source of nitrogen for the successful raising of tobacco when used with nitrate of soda or potash in a sufficient quantity to furnish a fourth of the nitrogen required by the crops. Cotton-seed hull ashes and high grade sulphate of potash are the most valuable sources of potash for tobaccos. Acid phosphate and phosphatic slag should be used in preference to animal phosphates. A standard fertiliser is one containing 3 per cent. of phosphate, 5 per cent. of nitrogen, and 15 per cent. of potash, but varying quantities are required according to the nature of the soil. Two hundred pounds to a ton of commercial fertiliser are applied per acre, but up to two tons are used where high-grade wrapper leaf or thin bright tobacco is desired.


1. THE TOBACCO PLANT

Tobacco Seeds. Tobacco seeds are very small, one ounce containing as many as 300,000 seeds. All the seeds are, however, not fertile, only about 75 per cent. germinating, so that allowing for imperfect conditions it may be

reckoned that 35,000 seeds in an ounce will yield plants. It is usual to sow at least three times the amount of seeds, so as to get a sufficient number of plants all of one size.

The Seed Bed. The best site for a seed bed is one with southern exposure, south-east, south-west, and western being the next in order. The bed should be near water, because the temperature is likely to be more uniform, and a sufficiency of moisture will be obtainable without artificial watering. In Cuba open spaces in the woods are the favourite locations for the seed beds, on account of the protection from winds afforded by the trees.

The most experienced tobacco growers burn the seed bed as a preliminary, the object being to destroy grass and weeds and grubs and insects that may be in the soil. Wood is spread on the soil in a thin layer and burned, more fuel being added from time to time, the burning being continued long enough to thoroughly steam and bake the ground.

When the soil has cooled, break it up with a hoe to the depth of two inches, rake off roots, and leave the surface level, loose, and porous. It should not be worked deeply. Having made the soil fine by repeated working, apply fine pig or sheep manure, or some good fertiliser, as the soil cannot be made too rich, because the object of the seed bed is to force the growth of the plants. The manure is well chopped-in and raked level again.

After burning the seed bed and before sowing the seed, enclose the bed with a frame. This is made of 1 in. plank, 8 in. to 10 in. wide, placed on edge, and nailed at the corners with diagonal strips of 1 in. by 3 in. plank. If no planks be available poles may be used. The bed is best not over 3 ft. wide, so that it can be reached from either side. To prevent the ravages of insects, and to keep the young plants warm, a covering of muslin is arranged as a curtain, so that the cover can be withdrawn when desired to admit sunlight and air.

Sowing the Seed. To obviate the difficulty of the impervious coating of the tobacco seeds, which delays germination, it is sometimes the custom to scratch the surface of the seed by rubbing the seeds with fine emery paper and then to moisten them with water in a bowl for 48 hours. Mix the seed in the proportion of ¦ oz. of seed to 2 quarts of wood ashes, corn meal, or sand, and sow carefully and evenly over the bed. A light-coloured diluent is best for the seeds, as it is easier to see where the seeds have been sown. Sow the mixture by the thumb and fingers, and after sowing sweep the bed carefully over with a brush, simply disturbing the surface of the bed, taking care not to bury the seed too deep. Next sprinkle the earth with water, and make it firm by laying down planks and standing on them. Water the bed twice a week, or oftener in dry weather. The seeds come up two weeks after planting, and their growth should be stimulated by watering with weak liquid manure. In about six weeks to two months the plants will be ready for transplanting, but before this takes place the plants should have been hardened by removing the cover gradually and increasing the time of exposure to the air day by day.

Transplanting.. The plants in the seed bed are planted out in the field when they have grown 4 in. to 6 in. high, although in Cuba the seedlings are allowed to become 8 in. to 10 in. high before this operation takes place.

Two or three weeks before planting, the tobacco field is harrowed and laid off in rows by means of a plough, the rows being 3 ft. to 3½ ft. apart. Open fields are usual, but in Florida a system of shading the fields with open lattice work is in vogue, which has the advantage of improving the leaf texture by moderating the sun's rays. It may be added that the distance apart of the rows varies in different parts of the world according to the kind of tobacco that is being grown, and whether hand cultivation or horse cultivators be employed.

The transplanting operation is best conducted in cloudy or damp weather. On the previous night the seed bed is well watered to loosen the soil, and the young plants are "drawn" early in the morning when still wet with dew, taking care not to injure the roots, and to keep as much soil adhering to the roots as possible. Take hold of each plant between the thumb and finger, and loosen the earth with a small garden fork. Put the plants gently into small boxes or baskets, cover with a damp cloth, and put in a shady place till the afternoon when the planting takes place. There are two methods of planting —by hand or machine. In hand planting, the plants are dotted at regular intervals by a staff of labourers, usually boys or women, while others follow and make a hole with a dibble, into which the roots of the plant are inserted. The soil is then pressed round the root, and the loose earth brought up with the dibble, the surface being left as loose as possible. This process is sometimes varied by one man walking along and making the holes, another dropping the plant near by, and a third setting the plants. When the soil is damp, watering is not required, but if dry, water is poured into the holes before inserting the plant. If the weather continue dry watering will be needed until the seedling is firmly established. In Cuba a quicker process of planting in furrows is adopted.

Machine Transplanting. Machine transplanting is practised in some districts. A planting machine, horse-drawn, carries the driver and two men or boys. The machine carries the water, which is run into each hole. It is stated that a man and two boys can plant two to six acres a day, about twice as much as can be accomplished by hand setting. In this stage care must be specially taken to have plenty of young plants ready, and only plant those of the same size in one field, so that all the tobacco will arrive at maturity together. Plant as early as possible after the time of frost has passed, and strive to have an early crop. In case of frost any young plants which show signs of having been affected should be replaced, and also any that have been bitten by insects within the first few days of transplanting

Weeding and Earthing Up. The tobacco field requires very careful cultivation, and must be systematically weeded before the plants increase much in size. The first weeding, which is best done by hand labour, should be about a fortnight after transplanting, and in this, as in subsequent weeding, the greatest care must be taken not to injure the leaves, as their value would be thereby much diminished. If the soil become hard or baked, it should be broken up with a hoe used towards the plant, so as not to take soil away from the plant. The last weeding, in fact, should be done with the object of earthing up the soil round the base of each plant. This encourages root growth, and enables the plant to more easily withstand winds. Machine weeding is practised, but the loss through leaf damage is more than with careful handwork.

Topping and Priming. The operation of removing the top or main shoot of the plant is called topping. It is done with the object of preventing the transference of nourishment to the seeds and to promote the growth of the leaves. The lowest leaves are also generally removed, as they are rendered worthless if left on, owing to laceration through wind lashing, but in some districts the lowest leaves are retained as a protection for the roots. The time for removing the top shoot arrives when flower buds begin to form, but before the flowers appear [2]. It is usual to retain from 10 to 12 leaves on each plant, as that is considered to be the average number that can be brought to perfection; but this is by no means a fixed rule, as from 15 to 20 may be left on in cases where the tobacco is intended mainly for cigar fillers or where the plant is very vigorous.

2. METHOD OF NIPPING OFF BUD

The topping of the plant causes it to send out buds or suckers at the junction of the leaves, and those suckers must also be removed, "suckering" being needed two or three times during the season. The side shoots or suckers are allowed to grow about 6 in., and are then pinched off to within 2 in. of the stem.

Insect Pests. The planter must closely attend to catching all grubs or caterpillars that infest the tobacco plants, as the quality of the leaves is soon injuriously affected.

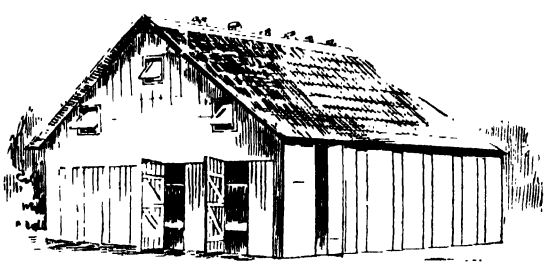
Some insects attack the plants when still below the soil, but for this there is no practical remedy. Slugs are very fond of tobacco leaves, and as a preventive a little powdered quicklime is scattered or blown on the leaves, or one may use an arsenical spray. Many kinds of caterpillars also infest the plants, hand picking by children being the most effective method of dealing with this pest. Balls of poisoned meal are sometimes distributed about the fields to attract insect pests, and much success attends the planting of clumps of *datura stramonium* to act as insect traps.

Leaf Diseases. Diseases which attack tobacco leaf often do considerable damage. One of these, known as mosaic disease, appears as light and green patches on the leaf, the cause not being well understood. The remedy is also obscure, although certain facts as to the cause are definitely known. As the disease is probably fungoid, well burned seed beds are desirable, and great care should be taken in planting so as not to injure the delicate roots.

Harvesting. In from four to six weeks after topping, the tobacco plant is ready for cutting down. The proper time for harvesting is a matter of considerable judgment and experience, as if the plant be cut before it be properly matured the leaves will cure dark, and, under some circumstances, will dry green, and never develop flavour. The following are the principle signs of maturity:

1. When a leaf is doubled up, and a nerve is pressed at the bend between the finger and thumb, it will break with a sharp crack if the leaf be ripe.
2. The leaf blade and leaf stalk bend towards the soil.
3. The leaf takes on a slightly yellow colour, and, on holding up a leaf, and looking through it more or less transparent spots like drops of oil are seen.
4. Walking through a tobacco field a characteristic smell of ripe tobacco is noticed.
5. On cutting across a branch a reddish ring will be seen if the plant be ripe.

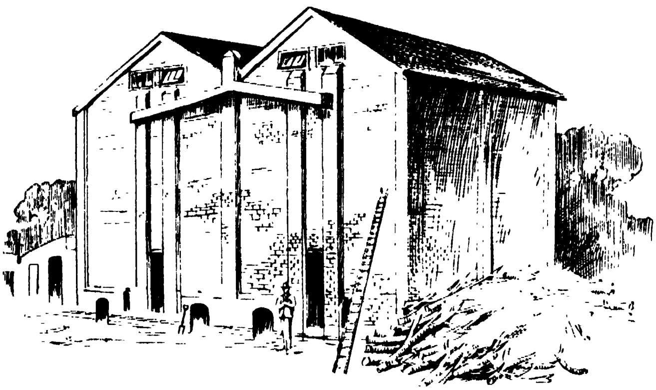
The leaves ripen upwards, and, in bright tobacco districts, the bottom leaves are harvested first. In other districts the plant is cut when the middle leaves are nearly ripe. When the leaves are separately detached from the stem they are placed in baskets and taken to the drying-sheds strung on twine or wires back to back. A string of leaves is then attached to a 4-ft. lath, and the laths hung up in the barn. The principal method of harvesting, however, is that which involves the cutting of the whole plant. The plants are cut off near the ground with a sharp knife, and the stalk split from the top half-way to the bottom. The splitting is omitted in some countries, and the whole plant strung on a curing-stick. In both methods the plant is exposed to the sun till it is wilted, or made limp enough to handle without injury. It must then be conveyed to the curing-barn with as little delay as possible. Cutting is best done late in the afternoon, as the cut plants are easily injured by the hot sun pouring down on them. Harvesting must not be attempted in the



3. TOBACCO BARN

morning when the plant is wet with dew. After rain it is wise to allow at least one fine day to intervene before harvesting.

Stacking in the Field. Instead of conveying the wilted whole plant direct to the barn, it is stacked on scaffolds on the field if the weather be fine and mild. From 8 to 14 plants are placed on a stick, and removed to the scaffold previously built in the neighbourhood. The sun begins the curing process by yellowing the plants and reducing the amount of moisture they contain. Both on the scaffold and in the curing-barn [3] spaces of from 8 in. to 12 in. are left between the sticks for the circulation of air. It should be added that, owing to the liability of the leaves to damage from exposure to the sun and weather, it is now considered wiser to get the crop safely in the barn at once without running any risk from climatic conditions. Special frame waggons are used for transporting the tobacco to the curing-barn, the object being to carry the plants so that they do not touch the sides or the bottom of the waggon. Otherwise the sticks of tobacco are piled on an ordinary waggon in layers with the butts and tops alternately on the outside. The leaves that are separately harvested are strung on twine in small shelters built outside the curing-barns.

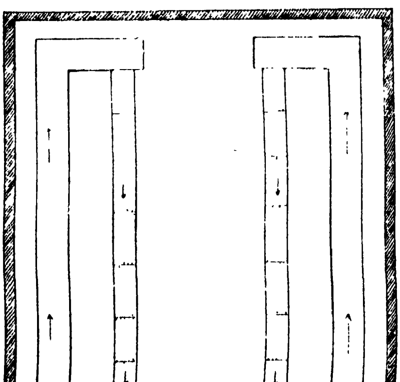


4. RHODESIAN TOBACCO BARN

Curing the Plant. The next process to which the tobacco is subjected is known as *curing*, and, as the quality of the product depends to a considerable degree on the care which is exercised at this stage, it will readily be seen that curing is one of the most important, as it is the most difficult of the processes. This should not be understood to mean that an inferior leaf can be made into first-class tobacco by suitable curing, but rather that the good leaf can be spoiled in the process through want of skill.

There are several methods of curing in vogue, which we will now consider separately.

Fire Curing. The method of curing by means of *open fire heat* is used for export tobaccos as such tobaccos stand transportation better than others. The burning charcoal or wood imparts a distinct flavour somewhat like creosote to the product. The following is a description of the process as usually followed: The curing-house is arranged with ventilation windows, and on the second day after cutting, the sticks upon which the tobacco was placed when cut are arranged in the barn. On the third day artificial heat is applied in the form of charcoal or wood—preferably the former, as there is less risk of burning down the shed. The heat is raised to, and kept at, between 70° F. and 80° F., the fires being kept up day and night until the lower part of the leaf shows signs of drying. This happens after about 24 hours, when the temperature is raised to 90° F., increasing by 10 degrees every 24 hours till 150° F. is reached. When all the moisture has evaporated from the leaf and the stem of the leaf the fires are discontinued, but resumed for a few hours if rainy or foggy weather come on or the leaf show signs of softening. When all the moisture has been driven out the tobacco is taken down, stripped from the stalk, and graded for the market.



5. PLAN OF FLUES

Flue Curing. In the process of *flue curing* the heat from an outside furnace is conveyed through the curing-house [**4** and **5**] by means of large iron flues or pipes. This method is used for curing bright yellow tobacco, the stages being:

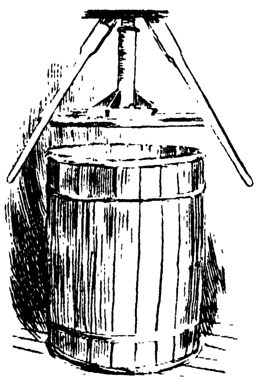
1. The yellowing process, when a temperature of 90° is kept up for from 20 to 30 hours.
2. Fixing the colour, the temperature being raised to 100° for four hours, and increased 2½ degrees every two hours, until 120° is reached.
3. The curing process proper, at a temperature of from 120° to 125° F., for from six to eight hours.
4. Stalk curing, at 125° to 150° F., the heat being raised to the latter temperature by five degrees an hour, and the heat continued till the stalk is thoroughly dried, which will be in from 12 to 15 hours.

A simplified process of flue drying is as follows: After the tobacco is cut it is placed in the curing-house, and the air warmed to 90° F. for two or three hours. The heat is then increased

rapidly to 125°, or even higher, if the leaf will stand it, and, after letting the heat stop at this degree for a few minutes, the fires are damped, and the heat gradually reduced to 90° F. The finishing part of the curing process is the same as we have explained in the previous process.

Sun Curing. The method of *sun curing* is practised in a part of Virginia, but as it involves many handlings of the tobacco, the expense for labour becomes a serious item. The process is, however, much valued by the manufacturers of plug tobacco, as the product is very sweet, and specially suited for chewing. Scaffolds are erected near the curing-house, and upon them is placed the tobacco as soon as it is cut. On the approach of a storm, the tobacco must be carried into the barn, as the colour and taste would be impaired if rain were allowed to fall on the leaves. The tobacco is exposed to the sun in this way for some weeks, until all moisture is dispelled. The storing and handling of sun-cured tobacco needs much more care than in the case of *fire* or *flue dried* leaf.

Air Curing. Cigar leaf, and other tobaccos of thin delicate texture, and smaller leaf and stem, are cured by *air*, in well-constructed curing-houses, in which wooden windows are arranged for ventilation purposes. The process lasts six to eight weeks, and during this time the temperature and moisture are regulated by opening or shutting the ventilators. Air-cured tobacco is of better flavour than that cured by other methods, being free from smoky taste, and, being more absorbent, it is largely used by manufacturers of chewing tobacco. White Burley tobacco cured in this way has a cherry-red to a red-brown colour.



6. SCREW PRESS

Fermentation. The *fermentation* or *sweating* process, which follows, is undertaken for the purpose of developing the aroma of the tobacco. The process is one often entrusted by the grower to the experts who specialise in this department. The method employed is known as *bulk fermentation*. The tobacco is sorted out into three grades according to the texture of the leaf, each grade being separately bulked or stacked in rooms heated by steam. The moisture of the air is also capable of being regulated. The size of the heaps varies according to the grade; for instance, if light shade leaves be required, 3,000 lb. to 5,000 lb. of leaves are placed in the bulk, while in the case of ordinary fillers, 10,000 lb. to 20,000 lb. are the average bulks. The leaves are piled up to a solid stack 5 ft. or 6 ft. high, and in definite order. The bulk is then covered up with canvas, and after a short time fermentation, as evidenced by a rise in temperature, takes place. The temperature must not be allowed to go beyond 130° F., to prevent which the heap is from time to time taken down and rebuilt. Some three to five weeks is occupied by the process. Steam is injected into the room when the leaf is in a very dry condition, but some leaf handlers prefer a spray of water. It is during the fermentation process that the lower grade tobaccos are *petuned*—that is, treated with flavouring ingredients to improve the aroma.

The temperature of the heap of tobacco is judged by putting the hand inside, or by using a thermometer, an automatic electric instrument being in use in up-to-date establishments.

Grading. The fermented tobacco is next graded and packed. In the case of Cuban tobacco, the leaves are made into *hands* of about 40 leaves each, the outside being bound round with bast into a *carotte*. Eighty carottes are made into a *bale*. Loose tobacco is packed or prized into *hogsheads*, averaging 56 in. high and 42 in. diameter at the head. Pressure is applied as the leaves or hands are being packed, the screw press used with hogsheads being shown in the illustration [**6**]. Care must be taken not to mix various kinds of tobacco in one package, as the market value of the tobacco is thereby diminished. Before being brought into use, tobaccos are kept in stock for from two to four years to age, the tobacco in this way becoming softer and mellower in flavour. The weight of tobacco in a hogshead varies according to the kind, from 600 lb. to 1,000 lb. of lighter tobaccos, up to 1,600 lb. to 2,000 lb. of dark leaf being averages. Half hogsheads are used for exporting to certain markets.

English Tobacco. By an Act passed in the reign of Charles II., the growing of tobacco is illegal in England and Ireland, an exception being made in regard to physic gardens, which were allowed to grow half a pole for medicinal purposes. The Act as regards England and Ireland has been relaxed in so far as experimental culture was allowed in 1886, at a time when, owing to agricultural depression, it was thought that the cultivation of tobacco might profitably be carried on at home. Experimental cultures were made by Lord Harris at Faversham, Mr. De Laune at Sittingbourne, and Mr. Wigan at East Malling. The experiment was deemed a success from some points of view, but it was hardly to be expected that tobacco of first rate quality could be grown without considerable experience as to the best seeds and most suitable soils for the crop.

Irish Tobacco. For some years, experimental tobacco growing has been carried on in Ireland. The Department of Agriculture has had charge of the arrangements. Colonel N. T. Everard has published an interesting account of his work in the "Journal of the Department of Agriculture." To encourage the experiments, a rebate of one-third of the duty has been granted for a period of five years, from 1904. Professor Keller, a tobacco expert, is studying the kinds of tobacco best suited for the various soils in Ireland, and this is held to be the crux of the question.

Continued

THE CAMPAIGN OF MAN

Sociology is the Study of Ourselves. The Science of Saving Society from Its Own Mistakes. The True Ethical Ideal must be Sociologically Possible

Continued from page 4124

By Dr. C. W. SALEEBY

THE present writer's estimate of the importance of sociology grows yearly—in this respect he questions not, resembling the estimate of all who are capable of learning. In so far as it is possible to speak of the root of any such matter as we have instanced, sociology "gets there," and time and again one finds that questions which appear at first sight to belong to subordinate sciences, and which the subordinate sciences can solve upon paper, just as the present writer can say upon paper, "Let every mother nurse her baby and you will have no infant mortality worth mentioning," can be solved in practice by the sociologist alone. He it is who deals with underlying principles. He it is who, in conspicuous contrast, for instance, to the unthinking kind of socialist, takes into account that supreme factor which we call human nature.

The Place of Ethics. And now a word as to the relations of sociology to the transcendent science of morality. Accepting as, at any rate, partially true that conception of morality which confines its gaze to human life as we know it on this earth, we see at once that, in one of its aspects, at any rate, sociology is inextricably interwoven with morality. The idea of justice, for instance, is, of course, a sociological idea as well as a moral idea, and even if abstract morals insist upon the truth that justice is justice, whatever the practice of men may be, yet the moment the practical moralist begins to ask himself how justice may be furthered, maintained and effected, whether by stern laws or by providing all citizens with good mothers, or by some other means, at that very moment the question of practical morals is seen to be a question of practical sociology.

There are a great many thinkers, chief among whom, perhaps, is Professor Lester Ward, the most distinguished of living American sociologists, who, having a too narrow conception of ethics, declare that it is not a science, still less a separate science, at all, but is merely a part of sociology. For Ward's discussion of this view, see his "Pure Sociology" (Macmillan, 1903). This, as it might be shown, is surely an exaggeration; but, at any rate, the fact which we are trying to emphasise remains—that while, on the one hand, sociology has the most complex and indissoluble relations with the sciences that are beneath it, on the other hand, it can never be dissociated from the one science which is above and beyond it.

Sociology a Science—and More. And this leads us on to another consideration which sociologists would do well to make more explicit, and the neglect of which has led to much misunderstanding. Just because sociology is intermixed with ethics, it has the peculiar character of that science. A pure science, whatever its subject matter, is properly concerned solely, exclusively, and cold-bloodedly with *what is*. Pure science has nothing whatever to do with *what ought to be*. The student of society, being a man as well as a scientist, cannot fail to have his own opinions as to what ought to be. He cannot fail, in his heart of hearts, to feel emotions of disgust or pleasure at the facts which he discovers. His case is thus totally distinct from that of the chemist, let us say. The student of atomic weights discovers that the mass-ratio of oxygen to hydrogen is 16. He is concerned merely to know that this is so. The fact will give him greater or less pleasure, certainly, according as it fits in with and confirms, or is incompatible with and throws discredit upon, other facts or supposed facts; but he passes no moral judgment upon the result he has obtained, and, whatever the result is, no question arises of any attempt to alter the facts. The efforts of all the chemists in the world could not change the atomic weight of oxygen, and there is no reason why they should.

The Search for Social Facts. Vastly different is the case of the moralist and the sociologist. If these students are to be worth anything at all in any permanent sense, they must, in the first place, treat their subject as a pure science. They must divest themselves of all interests in it save the interest which truth has for them as such. Science is concerned with what is and has been. The sociologist, if he is to call his study a science at all, must find out what is and has been. "His not to make reply": his not to say, "I approve or disapprove"; but precisely as the chemist is concerned to discover chemical facts, so the sociologist is concerned to discover social facts. Indeed, if one were asked to describe in a phrase the distinction between the modern conception of sociology and the standpoint of nearly all those who in the past have thought and taught and written about social matters, the reply would probably be that sociology as we conceive it now, is at any rate, whatever more it may or may not be, a deliberately cold-blooded, detached, impartial study of things as they are and as they have been, the past, of course, being the interpreter of the present. The sociologist in making this study is, one may suggest, to resemble as nearly as possible the gods as Plato imagined them. In opposition to the popular nonsense which believed that male and female deities, morally inferior to the average man and woman, constantly interfered with human affairs, it was

taught that such gods there were—taught for prudence sake, though it did not save Socrates—but that they did not interfere with human affairs. They sat upon Olympus "in god-like detachment," contemplating all things, understanding all the motives of men, seeing all the fashions in which they lived together, and the various consequences of all those practices, but never raising a finger on one side or another, and never caring a straw.

This exactly would be the attitude of the pure sociologist as such. It would be the ideal of sociology as a pure science—to make the science an omniscience of social facts, present and past, to record, classify, and generalise them, and put them into a perfect textbook.

The Sociologist Must Have Ideals. Now, it is quite certain that unless we recognise this conception of our business, unless we admit its validity, as far as it goes, unless we attain this impartial and, so to speak, careless point of view whilst we are ascertaining our facts, we shall, in the first place, forfeit the title to call ourselves scientific, and shall, in the second place, either mistake for facts what are not facts, or else shall make an artificial selection from the facts, choosing, perhaps, the few and insignificant which suit our prepossessions—as, for instance, in favour of authority or in favour of liberty—and omitting the many and weighty ones which prove that our prepossessions are false. Precisely the same necessity arises in the case of the moralist.

But there never yet was sociologist or moralist of any moment whatever who was not more than a pure scientist. The driving power, even in the case of such a costly and prolonged, despised and dreary enterprise as Spencer's "Descriptive Sociology," has always been the passion for what Carlyle called "that divine word reform"; and sooner or later every sociologist has renounced the purely scientific purpose and surpassed it. He has left the question of what is and has gone on to the question of what ought to be and how it *shall be*. The present writer certainly does not dare to question the value of pursuing truth for its own sake, and he is among the first to admit that the purely scientific conception of sociology is invaluable; but it is fortunately in the nature of the case impossible that anyone can set his mind to the study of social facts without being irresistibly compelled to ask himself how they can be modified. The student who did not ask himself this question would be as impossible a monster as the student of disease who studied it for its own sake and did not care two straws to ask whether the disease might have been prevented or might be cured.

Sociology a Campaign of Man. There are many splendid signs of the times which show clearly enough that the double conception of sociology—(1) as a pure science and (2) as a *Campaign of Man*—is making its way into the modern mind. Two distinct parties of people are approaching sociology. On the one hand there are the scientists whose own work lies in various departments of the science of life and living things. Every biologist, and every physician worthy of the name, for instance, is rapidly journeying to-day towards sociology. The greatest of national problems, the making of a vigorous and worthy people, is uniting medical men and sociologists, and with them also the students of heredity. These men of science are coming to discover that sociology provides them with an almost unsuspected storehouse of facts, and it is facts with which science is concerned.

The New Reformer. And from the other side sociology is being approached by the humanitarians, lovers of children, lovers of justice, lovers of liberty, lovers of the poor, social reformers of all kinds. Let us try to realise the significance, which has never yet been adequately recognised, of the change which the scientific idea is working in these times. Take, for instance, the great sociological questions of crime and punishment—criminology and penology. It is not so very long ago since a John Howard or an Elizabeth Fry set to work to do something for the wretched state of our prisons. They gave the miserable inmates, forsaken by man, their own personal service and sympathy, with all that this implied of moral regeneration. They immortalised their names amongst a "Christian" people because they did not content themselves with reading the 25th chapter of St. Matthew, but acted upon it. "I was in prison, and ye came unto me." It would be better never to write another word than to detract in any way from the splendour of their service and achievement.

But consider what the scientific idea is now beginning to accomplish in such cases as these. The deathless pioneers have done their pioneer work of awakening our consciences, but their successors do not follow the old plan. How all but hopeless was it to visit the prisons when the treatment of children, especially of naughty children, when the whole conception of crime, the whole social system that produced crime, the whole of the methods for repressing crime, were false and rotten, and when crime, and yet more crime, was the product of their putrefaction! Nowadays we do differently. The great scientific truth that causation is universal, and that all facts, being part of truth, are sacred and worthy of recognition—these are entering into the modern mind.

Reform on Wrong Methods. Nowadays, then, we have devoted students who study the facts of crime as the chemist studies the facts of calcium, and the day is dawning when, by a sane treatment of children, by the institution of methods of education which reckon with human nature and are based upon the facts of physiology, we shall abolish crime by preventing the formation of the criminal. This is obviously a more excellent way even than the visiting of the prisons—prisons which not one prisoner in ten thousand, brought up in a social environment adapted to his needs, would ever have entered. This particular illustration might be indefinitely multiplied, and it is impossible to exaggerate the practical importance of the change.

Hitherto, the social reformer has usually had more heart than head. The history of "charity" is the history of the consequences. Thoughtless charity has caused immeasurably more misery and wretchedness and sin and evil than it has ever relieved. Social reformers without number, and social efforts without number, have not only done more harm than good, but have actually brought our great ideal of reform into discredit—a pitiable end.

Heads and Hearts. But we are just now at the birth of the time when Science is to exert her beneficent sway—irksome though it may not infrequently appear—over the full heart of the social worker and the social reformer. The observer will find that bad schemes, promising an apparent immediate benefit, but threatening a lasting injury, have now to face the criticism not of one isolated philosopher here and another there, but of a whole host of thoughtful and well-informed people. In short, we are beginning to abandon the old method of trial and error. Sociology is teaching us that the past has made enough experiments if we would only look at them. Sociology is establishing generalisations which, like other generalisations or products of induction [see LOGIC], are capable of being used for purposes of deduction.

The reformer, the enthusiast, comes forward with a new plan, and sociology is able to say beforehand, in some cases at any rate, "No, this will not work," just as the student of Energetics [see PHYSICS] is able to say to the perpetual motion schemer, "No, this will not work." Furthermore, many social workers, whose good hearts are known to all, are having the possession of good heads as well revealed under the influence of the scientific atmosphere which is beginning to invest this subject. Hence they are being set to work to collect the generalised facts just as if they were one of the impartial deities to whom we have referred. Many of them are rapidly acquiring the temper which seeks to follow truth wherever she leads. In consequence, there are being rapidly produced books which contain matter of fact, and are as properly scientific in method, aim, and execution as the driest treatise on hydrodynamics. Conspicuous instances are furnished by Messrs. Rowntree and Sherwell's really epoch-making books upon the alcohol question, and any number more might be cited.

Discovering Ourselves. Throughout our course, then, we must endeavour to preserve the very difficult ideal, the two parts of which so many in the past have found incompatible, of (1) studying our facts as facts, and (2) studying our facts as means which will enable us *to effect further facts.* For sociology is unique among the sciences in that man makes the facts. We are far from saying, of course, that man in so doing is not determined by his nature and his education, by custom, tradition, mental inertia, and so on. But, nevertheless, the truth remains that the sociologist is in a unique position. It is as if an atom of carbon in the benzene ring [see CHEMISTRY] had set before itself the problem of discovering the constitution and potentialities of that ring. Itself is part, and a necessary part, of the facts which it is about to study, and (this, we think, being the most valuable part of our analogy) its comprehension of the facts will be determined by its position in the ring. If it be a short-sighted atom, it will know no more than that it is united by two hands to an atom of carbon on one side, by one hand to an atom of hydrogen, and by the other to a second atom of carbon. It will never occur to the short-sighted atom, perhaps, that its neighbour atoms are in exactly the same case as itself, just as it might have never occurred to an atom in another kind of molecule that its neighbours' circumstances are *not* the same as its own. But in any case the judgments of the atom are coloured and in part determined by its own circumstances and point of view.

The Intellectual Difficulty. The sociologist is in the same case. He is himself a part of the organism which he is studying, and unless he be far-sighted his comprehension of it will be no greater than the comprehension which the atom will have of a molecule, or which one of the white cells in your blood will have of *you.* Such a white cell would form one opinion of you; a nerve cell would form a very different one; and a muscle cell yet another. Similarly, the soldier turning to sociology will form one idea of society which can scarcely fail to differ profoundly from the idea formed by the workman sociologist or from that formed by the aristocrat sociologist. The problem is, being part of the organism oneself, to see it steadily and see it whole. There is the intellectual difficulty.

And then there is the difficulty that not only is every student of society himself a constituent of society, but also, unlike the atom or the cell, he has *will.* He is not only a fact, but the potential source of new facts, and these may be good or bad according as he is good or bad. The reader is asked to keep in mind this last sentence, because we are about to return to the idea which it contains—an idea which we believe to be the central truth of all sociology.

Truth is Never Impossible. Before we consider it, we must complete our study of the relation between the study of society and the study of morals by emphasising the most important proposition which has lately been laid down by one of the most distinguished living students of both these subjects, Professor Harald Höffding, of Copenhagen. This is the profoundly important proposition that morals and the moralist must recognise the existence of sociological truths. "The ethically right" (says Höffding) "must be sociologically possible." This statement may have no particularly attractive appearance, but it throws a most searching light upon the history of religious and moral systems. It condemns all ethical systems which are impracticable. This, of course, is not to say that it condemns ethical ideals as ideals, or that it demands the subordination of morality to the ugly facts of society and human nature. It means, as the present writer has tried to show elsewhere, "that the moralist, in seeking to

establish the true ideal, must be certain that his ideal is possible. It means that no ethical ideal can be true which—so to speak—would become impracticable directly it was realised. For instance, asceticism cannot be the ethical ideal, since a society of consistent ascetics would soon cease to exist."

"Untrue" Ideals. Asceticism can have value only as a temporary protest against sensuality. Abolish sensuality, and asceticism would be merely silly. Similarly, the doctrine that "life is for others," the doctrine that the ideal is complete self-sacrifice, cannot be regarded as ethically right, for it is sociologically impossible. It may serve a useful temporary function, but that it is essentially absurd must become apparent so soon as we try to conceive the social state in which everyone has reached the ideal. Self-sacrifice becomes impossible so soon as there remains no one who is willing to benefit by it. One man can be self-sacrificing, as a rule, only on condition that another is not. When all are equally and completely self-sacrificing, none can be so. Again, if every one is to live entirely for others, the result will not be the greatest happiness, but the greatest inconvenience and lack of economy. If I am to spend all my time in the pursuit of your happiness, and you all your time in the pursuit of mine, neither of us will be as happy as we might otherwise have been; and thus the purpose of our efforts will have been frustrated. Thus, unqualified altruism cannot be the ethical ideal, since it is sociologically impossible. Plainly, unqualified egoism is immoral: hence the ideal is neither "live for self" nor "live for others," but "live for self and others." This may claim to be ethically right, since it fulfils the first condition that it is sociologically possible.

The Great Central Truth. There are certain kinds of figures which one can build with cubical bricks and others which one cannot, this being an instance of the proposition that the nature of any whole depends upon the nature of its constituent parts. The central truth of sociology is precisely this, that the structure of societies depends upon the characters of its constituent individuals, can only be explained by reference to its units, and will be good or bad less on account of the fashion in which the units are related to one another than on account of the characters of the units themselves.

Now, let us take an illustration from chemistry. The characters of a compound may be said to be determined by two factors: (1) the number and nature of the atoms that go to compose each molecule of the compound, and (2) the manner in which those atoms are combined with one another. Similarly, the characters of a society are determined (1) by the nature and numbers of its constituent units, and (2) by the relations of those units to one another—the manner in which they are combined. One would not expect to go far in an understanding of the chemical compounds until one knew something of the characters of the elementary atoms. Similarly, one cannot go far in the study of a society unless one takes into account the characters of the individual man and woman.

Societies and Molecules. *But* there is a point at which our analogy breaks down, and much is always to be learnt at the point at which any analogy breaks down. As a matter of fact, if we consider the organic compounds we discover that the character of the individual atoms seems to go for very little. We may find two compounds of markedly different nature, which are yet isomeric, each containing the same number of the same kinds of atoms. In such cases it is the relation of the atoms rather than their nature that is all important. Now, the case of the supreme organic compound which we call a society differs immeasurably from that of the organic molecule, just because the units of the one are *mechanical*, whereas those of the other are *spiritual*. In the case of a chemical compound, even though we admit that the nature of the component atoms must be reckoned with, we constantly find cases in which it seems to be of trivial importance. The all-important thing seems to be the manner in which the atoms are bound together.

The Test of All Societies. Now, it is true that societies differ profoundly—as, for instance, a military and an industrial society—in consequence of the different manner in which their units are related, but this difference is itself only a sign of the differing characters possessed by the units. Yet again, there is a reaction between the spirit of man and its surroundings, so that, as never in the case of the chemical compound, the character of the society modifies and may most profoundly change the character of its units. Now, as we shall shortly see, a society is not an end in itself. The only reason for its existence is that it provides conditions for the production of worthy and happy life in individuals. *Therefore, the one sole criterion by which all societies are to be judged is their effect upon human nature and the conditions of life for the individual.*

Here, then, are our propositions dogmatically stated; they are among those truths which have only to be stated to find immediate acceptance. *The key to sociology is human nature. Every kind of society* that was, is, or will be, whether large or small, ancient or modern, barbaric or civilised, military or industrial, autocratic or democratic, dominant or servile, progressive, stable, or retrogressive, *depends for its characters, one and all, upon human nature, upon the individual, subjective, personal, spiritual, moral and intellectual characters of the individuals who compose it.*

Continued

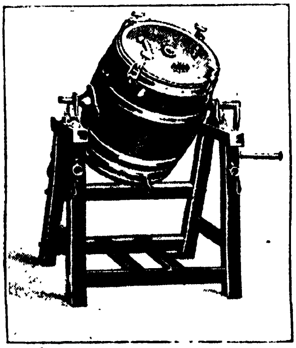
CHURNS & CHURNING

The Way to Use a Churn to Secure the Best Results. Good and Bad Butter. The Butter-worker. Making up Butter for the Market. Prices

DAIRY FARMING
continued from page 4213

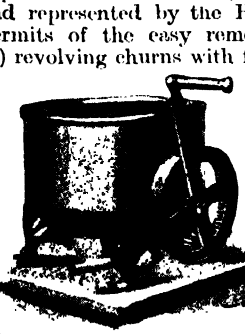
By Professor JAMES LONG

Forms of Churning. There are on the European market nearly 150 varieties of churns, of which many are modifications of well-known types, a few comparatively new in some feature, and the majority but reproductions, more skilfully finished and equipped, of churns which were used from half a century to a century ago. A good churn should contain as few angles as possible. If *beaters* be used, although they are quite unnecessary, giving additional trouble and sometimes preventing perfect cleansing of the interior, they should not be fixed. The opening of the mouth should be large, to facilitate the cleaning or removal of the butter; the lid should be simply and skilfully constructed that it may be fixed easily, quickly, and prevent the escape of cream; there should be a ventilator, and a tiny window of glass, while the size of the churn should be specially adapted to the work it is intended to perform.



25. END-OVER-END CHURN
(R. A. Lister & Co., Dursley)

Churns are made in various forms. Some are barrel-shaped, others square, rectangular, cradle, or millstone shaped; indeed there is scarcely any limit to the form which they now assume in the hands of manufacturers [27]. The barrel-shaped churn is perhaps the most popular—we refer to that which revolves end-over-end—for the reason that it contains no beaters, and that the lid is large and the opening correspondingly so [25]. The best utensils are made of oak, polished outside, and skilfully finished. The chief systems adopted by churn makers are: (1) churns fixed with movable beaters or dashers within, a type common in Denmark, Sweden, and Germany, and represented by the Holstein churn, which permits of the easy removal of the butter; (2) revolving churns with fixed beaters, some of which are removable through the mouth; (3) revolving churns without beaters or dashers; and (4) the fixed churn, within which a disc revolves with great rapidity.



26. DELAITEUSE, OR BUTTER DRYER
(Dairy Supply Co., Ltd.)

Although the end-over-end barrel churn is popular for the reasons already given, there is probably no churn in the market which does better work than the Holstein. In good hands, however, good butter can be produced and a minimum quantity of butter fat left in the buttermilk in any well-made churn.

What the Churn Does. The object of churning is to extract the fat from the cream in the form of fine granules [28], which, by washing, can be made up into sweet, well-keeping butter. Where butter is over-churned [29], or churned into a lump, it is practically spoiled, for the buttermilk, which contains impurities, cannot be extracted. If churning, however, cease when the butter has *broken*, as it is termed, into granules about the size of grains of rice, the washing which follows removes the buttermilk, and consequently the casein and sugar that it contains. If the temperature of the cream be too high, these granules are soft, and adhere to each other, and thus prevent perfect washing. If the granules are too small, like grains of mustard seed, for example, washing is still difficult; hence the preference of skilled makers for the size which has been mentioned. There must be no greasiness; on the contrary, by skilful manipulation and the aid of very cold water, the rice-like grains may be rendered firm and crisp, and perfect washing facilitated. No process of churning or washing, however, will enable the most skilled of makers to produce good butter from imperfect milk or cream.

How to Use the Churn. The churn should never be filled too full of cream; not, indeed, more than one half. The larger the quantity of cream placed in the churn, the longer the time occupied in bringing the butter, while the smaller the quantity, the shorter the time occupied. For instance, in a churn intended to deal with 60 lb. of cream, 16 lb. pro-

27. DIAPHRAGM CHURN
(Pond & Son, Ltd., Blandford)

duced butter in 28 minutes; when double the quantity of cream was churned, 39 minutes were occupied; and when four times the quantity of cream were used, 85 minutes were occupied—the percentage of butter produced being slightly smaller with the increase in the quantity of cream. Cream, however, like milk, does not all churn alike; something depends upon the individuality of the cow, and something upon


28. WELL-CHURNED BUTTER

the food consumed. Speed, too, exerts some influence, and, as we have seen, the quality of cream employed.

Influence of Cows' Food on Cream. We have much yet to learn as to why the cream of one cow is more churnable than that of another, and also why cream produced from some classes of food is more churnable than that produced from others. It is, however, well known that where cows are fed upon grass in summer, the percentage of fat obtained in churning is greater than when the same animals are fed upon hay and certain other dry foods in winter. The speed adopted in churning varies with the churn and its size; the number of revolutions per minute should be noted, together with the results which follow, and the careful operator will quickly learn what speed to adopt. With the disc churn, butter may be produced in five minutes; indeed, with almost any class of churn rapidity is followed by the production of the butter in a shorter time, but sometimes at the expense of either quality or quantity. With the average churn, butter is produced in from 30 to 40 minutes, the number of revolutions varying from 45 to 55 per minute.

Modifying the Temperature. We have already referred to the influence of temperature, but, whatever figure be adopted, it cannot be more than approximate, for the reason that the fats of which butter is composed are not all constant in quantity; the solid fats, for example, vary as between winter and summer, and these fats possess different melting points. The influence of temperature is also modified by the material of which the churn is made, the consistence or richness of the cream, and the temperature of the dairy in which the work is performed. A high temperature must always be avoided, if it be sufficient to produce an approximate oiliness in the cream. If churning be protracted and the cream swell in volume, or froths, and become bitter and "sleepy," churning should be stopped, and half the cream removed before beginning again; when both lots have been converted into butter, the butter should be washed with sweet milk, and salted with half an ounce of salt to the pound.

What Occurs inside the Churn. Before beginning to churn, the vessel should be scalded and brought as near as possible to the temperature of the cream. If the temperature be, however, too high, it may be reduced with cold water; or, if too low, by scalding again. Neither soap nor soda should ever be used to clean a churn. After starting to churn, the gas within (carbonic acid) should be allowed to escape by pressing the ventilator. Steady work should be continued until the butter breaks. This may be noticed by watching the glass of the window, or by listening to the splashing of the cream, which changes from a dull thud to something like the splashing sound of water; while the glass, hitherto covered with a film of cream, becomes almost clear, and tiny grains of butter may be noticed adhering to it. At this point the butter should be examined, and, unless the grains be quite distinct and crisp, a little cold water, as near 40° F. as possible, may be added. The churn may then be turned gently for a few revolutions, in order to increase the size of the grains to that of rice or small wheat [28]. When this point is reached the buttermilk may be drawn off through a strainer, and more cold water added for the first washing. If the temperature has reached 58° F. to 60° F. the colder the water the better. The churn may then be rocked and the water drawn off through the sieve. Two or three similar washings may follow, rocking each time, until the water comes away quite clear. The work in the churn may then be completed by washing with brine made by adding one pound


29. OVER-CHURNED BUTTER

of dry salt to 1½ gallons of water. After drawing off the brine, the grains of butter may be removed from the churn with the butter-scoop, either on to a wooden trough which some persons use for draining purposes, or to the butter-worker, where it may remain in a pile in the grain until it has drained sufficiently to be ready for working. Some makers, however, remove the granules of butter into a *Delaiteuse* [26], a hand machine

which, revolving at high speed, removes the water by centrifugal force.

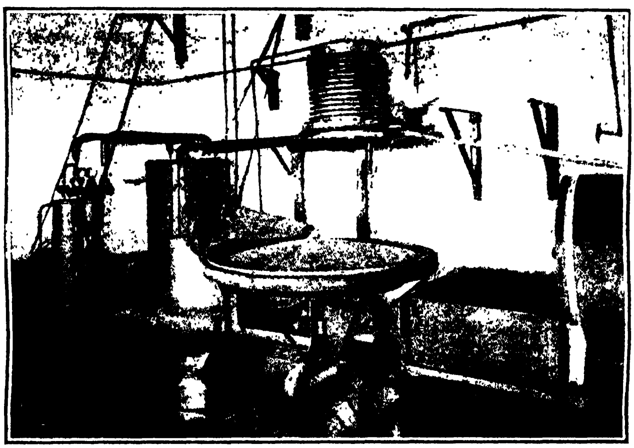
The Butter-worker. The butter-worker is made in two forms—circular [31] and rectangular, its floor being either high or low in the centre in the case of a circular machine, or sloping from the centre to the ends in the rectangular machine to help drainage; but in either case a fluted roller [30] passes over the butter, squeezing out the moisture, and at the same time making the mass of grains homogeneous. Care must be taken not to smear the butter or to cause friction, which results in spoiling the grain, nor must butter be worked when it is too soft, or upon a table which has not been prepared by scalding, salting, and finishing with cold water.

30. MAKING UP BUTTER
e roller placed a y beneath
(T. Bradford & C London)

In making fine, fresh, mild butter, brining alone is sufficient. For mild salting, ¼ oz. to 1 lb. is added by the aid of a dredger when the butter is on the worker. Slightly heavier salting is the result of ½ oz. to 1 lb., while for preserving purposes ¾ oz. may be employed. The salt used should be of the purest obtainable, ground almost as fine as flour, and well dried in an oven. Salt attracts moisture, and where excessive moisture is present in butter coarse salting is followed by a mottled appearance, which renders butter almost unsaleable. Butter should never be artificially coloured. If it be pale it may be improved by the addition of Jersey or Guernsey cattle to the herd.

Handling to be Avoided. In *making up* butter [30], prints and moulds are no longer used in this country in the ordinary way, although quite common on the Continent, where butter is moulded by implements or machines, which at the same time cut it into various weights. English butter is usually made in pound or half-pound rolls, although occasionally these are stamped. Butter should never be touched by the hand. It is a well-known fact that the pores of the skin are the media through which perspiration passes, this being secreted by glands, and containing not only carbonic acid, but small quantities of area. In potting or preserving butter, well-made tubs or boxes, which should be lined with greaseproof paper, or glazed earthenware vessels should be used. Butter for preserving should be churned at 56° F., well drained, dried, salted with three-quarters or one ounce of salt to the pound, and packed carefully so that air is excluded. If it be kept at from 35° F. to 37° F. it will keep well and long, but great care is necessary from the beginning to the completion of the process. In judging butter, flavour takes the first place, followed by grain and toughness, and lastly by colour and firmness. Where points are adopted, half are given for flavour and a quarter for grain.

Prices. The value of milk for butter production depends upon its richness in fat. The practice of paying the farmer upon the basis of quality is not only a just one but it offers him an inducement to improve the quality and character of his herd. The milk as it arrives at the dairy or factory should be sampled and tested either daily or weekly, in the latter case through the medium of a composite sample by the Gerber or Babcock machine, and the farmer credited with the percentage of fat which his milk contains, and he should be paid accordingly. Let us suppose that three farmers, A, B, and C, supply milk in similar quantities for a similar period, containing respectively 3, 3½, and 4 per cent. of fat. Instead of each man receiving a similar cheque, B would receive one-sixth more than A, and C one-third more. Thus, if 5d. per gallon were paid for milk containing 3 per cent., 6d. for milk containing 3½ per cent., and 7d. for that containing 4 per cent. of fat, each man sending 30 gallons per day, or, say, 10,000 gallons per annum, B would obtain £41 more than A, and C £83 more. The system of paying on the basis of fat percentage, however, may be varied, so that each farmer may receive payment for each pound of fat which he supplies in his milk, the quantity being calculated on the basis of the fat percentage. Reform in this direction is much needed.



31. CREAMERY, SHOWING REFRIGERATOR, CYLINDRICAL COOLER FOR RIPENED CREAM, BUTTER-WORKER AND PORTION OF CHURN
(By Permission of W. Douglas & Sons, Putney)

Continued

Group 13
GEOGRAPHY
30

Continued from page 4178

RESOURCES OF SOUTH AMERICA

Mountains, Forests and Grasslands. The Great Rivers. Resources and Occupations of the Various Republics

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

SOUTH AMERICA (7,000,000 sq. miles) extends from the Isthmus of Panama to the southern extremity of the New World. It is longer than North America (4,600 miles between Capes Gallinas and Froward), but not so broad (3,200 miles between Capes Parina and Branco).

Coast Line. The Pacific States are Colombia, Ecuador, Peru, and Chile. The Caribbean States are Colombia and Venezuela, and farther east are the British, Dutch, and French Colonies of Guiana. The eastern or Atlantic States are Brazil, Uruguay, and Argentina. The inland States are Bolivia and Paraguay. All are republics except the British and Dutch Guianas.

Gulfs and Islands. The compact form and short coastline contrast strongly with the indented shape and extensive coastline of North America. Notice the absence of inland seas, gulfs, peninsulas and islands. The southern coast of Chile is fringed with islands and indented with fiords recalling the very similar coast of Norway. The island of Tierra del Fuego is separated from the southern mainland by Magellan Strait, a stormy channel leading from the Pacific to the Atlantic. Farther out in the Atlantic are the Falkland and South Georgia Islands.

Mountains and Rivers. There is a marked similarity in the disposition of the mountains and plains of North and South America. South America, like North America, is bordered along the whole length of the Pacific coast by a high, broad mountain system consisting of many parallel chains. These are the Andes, or South American Cordillera, corresponding with the North American Cordillera. From their eastern base stretch vast plains, covered with forest or grass, corresponding with the central lowlands of North America. East of these great lowlands rise the Atlantic Highlands, also corresponding with those of North America. The Amazon, which corresponds in position with the St. Lawrence, separates the Guiana Highlands, comparable with the Labrador Highlands, from the Brazilian Highlands, comparable with the Appalachians of the United States. The different shape of South America prevents the formation of a south-flowing river on the scale of the Mississippi, with which the Paraguay-Parana corresponds. The Orinoco, both in position and direction, suggests a comparison with the Saskatchewan-Nelson. Interesting as these resemblances are, they are more superficial than real, and must not be pushed too far. The fact that the southern continent is broadest in the latitude of the equator while the northern continent is broadest in the latitude of London sufficiently indicates how widely the two continents must differ.

The Andes. The structure of the South American Cordillera, or Andes, is not yet thoroughly known. Fitzgerald, Whymper, and Conway have climbed the loftiest peaks, but, brilliant as such feats are, they teach the geographer less than does the careful survey of a region area by area. The nature of the Andean region makes this process a slow one, and it will probably be long before we know the South American Cordillera as we know that of North America.

The Coastal Ranges. The coastal ranges of South America are not continuous. In Colombia they form a densely-forested and little-known region, which is separated from the Cordillera proper by a depression in which the Atrato flows north and the San Juan south. Further south in Ecuador this depression is represented by the valleys of Western Ecuador. From Guayaquil to Arica the coastal range is absent, but south of Arica it reappears, the Atacama Desert occupying the depression between it and the Cordillera. South of Aconcagua it can be traced in the mountains which form the western boundary of the narrow valley of Chile. South of 42° the coastal range is represented by the islands of Chiloe, Chonos, and Queen Adelaide, and the depression by the channel which separates them from the deeply fiorded coast of Southern Chile.

The Andes of Colombia. In Colombia the Cordilleran system consists of three chains, separated by long, narrow, parallel river valleys. These chains diverge to the north, but converge in the south to the node or knot of Pasto. Between the Western and Central Cordilleras is the valley of the Cauca, an affluent of the Magdalena, which flows parallel to it between the Central and Eastern Cordilleras. The highest part of the Central Cordillera is in the south where the great volcanoes of Tolima and San Ruiz rise to 18,000 ft. The Eastern or Bogota Cordillera, which is not volcanic, forks, the western fork running due north to the Sierra de Santa Marta of the Goajira Peninsula, while the eastern fork is succeeded by the Sierra de Merida (15,500 ft.) and the northern coastal range of Venezuela.

Many fine views are obtained from summits in the Colombian Andes. From the mountains above Bogota a magnificent view is had of Tolima and San Ruiz, nearly 100 miles to the west, their great frozen sides glittering under the tropical sun.

The Andes of Ecuador. In Ecuador two main chains can be traced, both containing many lofty volcanic peaks. In the western chain are Chimborazo (20,500 ft.), Illiniza (17,500 ft.), and many others over 15,500 ft.

The eastern peaks include Cotopaxi (19,600 ft.), Antisana (19,300 ft.), Cayambe (19,200 ft.), Sangai (17,500 ft.), and others almost as high.

Volcanoes. Sangai and Cotopaxi are seldom at rest. All this region, as well as Colombia, is often visited by disastrous earthquakes.

The snows of the Eastern Cordilleras of Colombia feed the many streams which rush down precipitous and densely-forested gorges to form the tributaries of the Orinoco. Only the extreme south of the Colombian Cordillera sends its waters to the Amazon, to which also flow the waters of the Eastern Cordilleras of Ecuador, through scenery equalling the finest parts of the Himalayas.

The Andes of Peru and Chile. The Andes in Peru form three chains, which increase in height from north to south. These are separated by narrow river valleys recalling those of Colombia. Between the Western and Central Andes is the valley of the Marañon, the principal head stream of the Amazon. The Central Andes are separated from the Eastern Andes of Peru by the valley of the Huallaga, which flows parallel to the Marañon, and like it goes to form the Amazon. Both turn east and break through the eastern chain in magnificent gorges. The three ranges converge towards Pasco, near the source of the Huallaga, south of which the height of the peaks increases. The Ucayali, a tributary of the Amazon, gathers up the many streams which flow from the Eastern Andes through densely forested and little-known country. The eastern or Cordillera Real now begins to diverge from the western, and between the two lies the lofty plateau of Bolivia, the Tibet of the Andes. Both chains contain lofty peaks. El Misti and others in the western chain are not far short of 20,000 ft., while Illimani and Sorata in the Cordillera Real are over 22,000 ft.

The Andes of Chile and the Argentine. In the north of Chile and the Argentine, the Andes form three ranges. The eastern chain is divided from the Central Andes by a plateau over 4,000 ft. above the sea. These three chains are replaced by the western coastal and main or eastern chain further south. This main chain contains the highest peaks, including Aconcagua (23,000 ft.), the culminating point of the New World. Though Aconcagua can be clearly seen from the Pacific coast, its snows feed streams which flow to the Atlantic, 700 miles away.

After every kind of hardship, the summit of Aconcagua was reached in 1897, and the continent lay spread out below. "The line of the Pacific stood high on the horizon, stretching away for 150 miles. Range after range of mountains could be clearly seen between Aconcagua and the ocean. We seemed to look right down into the valleys between these ranges. Fifty miles away stood the great snow mass of Mercedario, one of the highest mountains in the Andes, towering above all the surrounding ranges. Of the pampas, or plains, of the Argentine we could not see anything; there were too many high ranges between. To the south the clouds were not high enough to cut off the magnificent view of Tupungato (22,000 ft.) and the great range to the north, including the beautiful peaks of Pollera (19,000 ft.), Navarro (19,500 ft.), and Juncal (20,500 ft.), which so distinctly mark the boundary line between the two republics." To the north the Cordilleras widen out, until at lat. 32° 50′ they rise up from Mendoza and continue almost to the sea coast, a distance of 150 miles.

The Cumbre Pass. At the base of Aconcagua is the Cumbre or Uspallata Pass, 12,800 ft., leading from Chile to the Argentine. There is no pass so low as this for many hundreds of miles to the north. It is the route followed by the transcontinental line from Buenos Aires. A tunnel below the summit of the pass is in course of construction.

The Andes South of Aconcagua. South of the Cumbre Pass the Andes are narrower, but still very lofty. The great plain in which Santiago is situated is not more than 45 miles to the west from Tupungato. These 45 miles are filled with range after range of high mountains. From the top of Tupungato eastwards, a man can look down almost into the great plain of the pampas.

Southwards the range sinks as well as narrows, to disappear at last beneath the waters of the ocean. The mountains rise steeply from the Pacific, and the sea has penetrated far up the valleys, forming fiords like those of British Columbia. Beyond lies a fringe of islands, representing the almost submerged coast range. At the eastern side are many picturesque lakes which recall those of Switzerland or of Scotland.

Central Lowlands and the Orinoco. The Central Lowlands may be grouped as the Orinoco Lowland, the Amazon Lowland, the Plate or Paraguay-Parana Lowland, and the Patagonian plateau. Between the Orinoco and Amazon Lowlands rise the Guiana Highlands in the east, while the Brazilian Highlands separate the Amazon and Plate Lowlands. The Orinoco rises in the Sierra Parime, the south-west part of the Guiana Highlands, round the western and northern base of which it flows in a semicircular course of 1,500 miles, the direct distance between its source and mouth being only 500 miles.

The traveller approaching the coast of Venezuela notices far out to sea the milky waters of a great river, sharply contrasting with the blue salt water. This great outflow of fresh water convinced Columbus of the neighbourhood of a continent, for no West Indian island could feed so great a river. Six or seven of the 70 channels which cross its delta are navigable. A waste of mangroves fringes the coast, succeeded inland by a labyrinth of vegetation, through whose innumerable creeks dart the canoes of half-naked Indians. Beyond the swamp-forest of the delta the country opens out on the west bank to the grassy llanos, which stretch to the horizon, apparently level, but really rising imperceptibly to the forests, or selvas, at the eastern base of the Andes.

The grass is very luxuriant in the wet season, but withers in the dry season, when the vast

herds of cattle, horses, and mules, suffer terribly from hunger and thirst.

The tributaries of the Lower Orinoco are the Caroni and the Caura, swift streams rushing down from the densely-forested wilds of the little-known Guiana Highlands. Between their confluences the Orinoco narrows, and there, at the head of tidal navigation, is built Ciudad Bolivar. The Lower Orinoco becomes enormously swollen in the rainy summer months, and floods the lowlands for many miles.

Quite different in character are the left bank tributaries—the Meta, Guaviare and others, which come from the Eastern Andes across the llanos. These are navigable for hundreds of miles, though in the dry season sandbanks may interrupt the channel. The Orinoco itself is navigable as far as the Atures and Maipures rapids, above the confluence of the Meta, where the river descends from the highlands to the lowlands. These rapids are a step-like series of cascades where the river, measuring some miles from bank to bank, is broken into innumerable narrow channels by rocks and islands all densely clothed with palms and other tropical trees.

The course of the Upper Orinoco is through the forests of the Guiana Highlands. At no great distance below its source the river forks. The Cassiquiari, the western branch, never rejoins the main stream, but connects with the Negro tributary of the Amazon.

The Amazon. The Amazon, the largest river in the world, rises about 60 miles from the Pacific, and after a course of nearly 4,000 miles, pours its waters into the Atlantic. Its longest head-stream is the Ucayali, but the Marañon is generally regarded as the source. Both the Marañon and the Huallaga rise in the Peruvian Andes, near Cerro de Pasco, one of the highest towns and richest silver mines in the world. Both flow north, descending from their lofty sources in a series of cataracts and rapids. Both at last turn east and break through the outer or eastern Andes to the lowlands, forming magnificent gorges, through which the river roars in cataracts of terrible beauty. Soon after entering the lowland the rivers unite, and, after receiving the Ucayali, are known as the Amazon.

The Amazon Forest Lowland. Nearly all the Amazon Lowland—an area three-quarters that of Europe—is covered with dense forest, or *selva*. No traveller can describe its wonders, the luxuriance of its vegetation, and the profusion of its species. In it one may journey for weeks in any direction without ever passing out of the world of trees. The eye itself cannot take in the vision. "The whole glory of these forests," says the great naturalist Wallace, "could only be seen by sailing in a balloon above the undulating, flowery surface. It is, indeed, a magnificent sight to behold a great tree covered with one mass of flowers, and to hear the deep hum of millions of insects gathered to enjoy the honeyed feast, but all this is out of reach of the admiring naturalist. It is only by the river banks that we can see all the beauty of the tropical vegetation. There we find a mass of bushes, shrubs, and trees of every height, rising over one another, all exposed to the bright light and fresh air, and putting forth within reach their flowers and fruits which in the depth of the forest only grow far up on the topmost branches. The huge buttress trees, the fissured trunks, the extraordinary air roots, the twisted and wrinkled creepers, the elegant palms, are what strike the attention and fill the mind with admiration."

The Middle and Lower Amazon. Through this vast forest, the greatest in the world, flows the Amazon and its mighty tributaries. Of those from the north the Rio Negro is the largest. Purus, the long Madeira, Tapajos, and Tocantins all come from the south, so that the stream of the Amazon is fullest during the southern rainy seasons. The main stream is often miles in width, bearing many verdurous islands on its broad bosom. It breaks up into many parallel streams or side channels, along which one might travel through the dark recesses of the forest for many hundreds of miles without ever returning to the main stream. Along these, Indian tribes who make the forest their home push their way in their rude canoes. On the main stream there is regular steamer navigation. The main stream is navigable to where the Marañon issues from the eastern wall of the Andes, and most of its tributaries almost to their sources. The Madeira, the most important, is navigable to the base of the Bolivian Andes with a break where there is a succession of rapids.

The Amazon does not form a delta, but a great estuary, which for the last 250 miles is 50 miles wide, and at its mouth as much as 500 miles. Up this funnel the Atlantic tides rush for 500 miles, often with great violence, forming formidable waves. The influence of the river freshens the sea water for 150 miles out to sea. Steamers enter the Amazon by the Para River, south of the island of Marajo, through narrow and intricate winding channels.

Resources of the Amazon Basin. The products of the forest are too numerous to be mentioned. The most important is rubber. The timber would be of enormous value if it could be conveyed to the markets of Europe and Asia. The region will develop either by the slow growth of small plantations, carved out of the forest by the natives with infinite labour and patience, or by trading syndicates which will utilise the timber in the course of clearing the forest, and employ native labour for all work involving exposure to heat and rain.

The important towns of the Amazon are all at the confluence of important tributaries—Nauta, where the Ucayali joins the Marañon; Manaos, at the confluence of the Rio Negro, commanding many routes; Obidos, at that of the Trombetas; Santarem, at that of the Tapajos; and Para, at that of the Tocantins.

The Plate Lowlands. If the Amazon Lowland be a typical forest land, the Plate Lowland is a typical savana land. The Paraguay, the main stream of the rivers flowing to the Plate estuary, rises in the plateau of Matto Grosso, in the

145. SOUTH AMERICA

Brazilian Highlands, and flows due south, receiving the Pilcomayo and other tributaries from the Andes. These cross the Gran Chaco, with its forests and plains of grass dotted with innumerable fan-palms, and then emerges into the treeless pampas. They pass thus through country similar to that crossed by the Meta and other Andean tributaries of the Orinoco. This region, like the llanos of South America, the prairies of North America, the steppes of Europe and Asia, and parts of the veldt of South Africa, is a great pastoral land, broken up for cultivation in the moister richer parts. Mounted horsemen, the gauchos, generally with Indian blood in their veins, follow up vast herds of cattle and horses which roam over the infinite reaches of the pampas.

The Patagonian plateau lies east of the Andes, descending by low terraces to the narrow coastal plain. It is a pastoral land, too dry for much agriculture.

The Eastern Highlands. As in North America, the Eastern Highlands are the worn-down remains of a very ancient region, far older than the higher Western Highlands. They are tablelands of the African type, and are divided by the Amazon Valley into the Guiana Highlands to the north, and the Brazilian Highlands to the south of that river. Both are only very partially explored.

The Guiana Highlands. The Guiana Highlands are, in a sense, an island, enclosed between the Atlantic Ocean, and the Orinoco and Amazon rivers, which are connected by the Cassiquiari. The whole region is rugged and difficult to penetrate, covered either with dense forest, or with savanas of giant grass. The rivers are wild torrents, forming innumerable falls and rapids, and of little use as routes. The interior of this region is practically uninhabited. As recently as 1900 an exploring party suffered intense hardships on the Caroni, and the majority perished of the exhaustion caused by the difficulty of clearing a track and of obtaining food.

The highest part of the Guiana Highlands is round Icutu (11,000 ft.) and Roraima (8,500 ft.). The latter, a magnificent table mountain, rising above a sea of forests, sends its waters to the Caroni tributary of the Orinoco, to the Essequibo River of British Guiana, and to the Rio Branca tributary of the Rio Negro, whose valley drives a wedge of lowland far into the highlands. The Sierra Parime, rising steeply above the Amazon Lowland, is the source of the Orinoco.

The Brazilian Highlands. The Brazilian Highlands are enclosed between the Atlantic Ocean and the Amazon and Paraguay-Parana rivers which, in the rainy season, are connected by the Guapore branch of the Madeira. From Cape Frio, north of Rio Janeiro, a line of high ground, forming the Minas Geraes, Goyaz, and Matto Grosso plateaux, separates the rivers flowing north to the Amazon from those running south to the Paraguay-Parana, or east to the São Francisco. The highest summit is Itatiaya (9,000 ft.). Much of this region is densely forested, and difficult to penetrate. Elsewhere it is a savana land, well wooded in the Matto Grosso and other regions.

Climate. Most of South America lies between the tropics, and has a tropical climate. The continent is broadest in the equatorial region, and the climate of much of the interior is always hot. Contrast this with North America, where the continent is broadest in temperate latitudes and the interior has a very extreme climate. The hottest region in summer (January) lies between the mouths of the Amazon and Plate. The hottest region in July is the northern seaboard. Elevation must, of course, be taken into account. In the Andes we have the same succession of zones (*tierra caliente, tierra templada*, and *tierra fria*) as in Mexico and Central America. South of the Plate Estuary the summers are those of Southern Europe, and the winters those of the British Isles. In the extreme south, both summers and winters are those of our own country.

The rainfall of the Amazon basin is heavy at all seasons, but especially at the equinoxes. The Guiana coast, also, has heavy rains at all seasons. Dry areas are found on the west coast in Peru and Chile, in the trade wind area, and in the lee of the Eastern Andes, in the west wind belt. The rest of the continent has a rainfall of from 40 in. to 60 in., with dry winters. There is a relatively dry area in Brazil, round the middle of São Francisco, where the Brazilian Highlands are high enough to intercept the Atlantic winds. The valley of Central Chile has winter rains, and may be compared with the valley of California.

Vegetation. We have already seen how dense is the vegetation of most of tropical America. The Amazon forest is the greatest in the world. All tropical species are represented, but rubber is the most important commercially. On the slopes of the Andes, the cinchona-tree, furnishing quinine, is extremely abundant.

These selvas of the Amazon Lowlands pass into the llanos of Venezuela in the north and the pampas of the Argentine in the south. There are open or parklike woodlands or campos in many parts of the Brazilian Highlands. Patagonia is poor steppe land, with the characteristic thorny vegetation of a dry climate. The Pacific slopes of Southern Chile have coniferous forests like those of British Columbia.

The cultivated plants are mainly those of the tropics. Cacao is an important product of the cultivated slopes of the Andes, sugar of the Guiana Lowlands, and coffee of the cultivated Atlantic slopes of the Brazilian Highlands. Outside the tropics in the Plate Lowlands wheat is a crop of ever increasing importance.

Population and Occupation. No continent presents greater contrasts than South America. Round the coast we have a few great cities which will bear comparison with any in the Old or New World. In the heart of the continent we have tribes of wandering Indians, ignorant of all arts except hunting, the manufacture of the needful weapons, and the building of rude canoes. Between the two every grade of civilisation is found.

South America, backward and thinly peopled, presents a striking contrast to North America, with its denser and intensely progressive population. The explanation is mainly geographical. The density of the forest in the lowlands and the rugged character of the highlands have made the opening of routes very difficult, and have checked the growth of population and the spread of civilisation over a great part of the continent. This is most marked in the forest region, where the native tribes are at a far lower level than were the prairie Indians of North America. It is instructive to compare these backward forest tribes with the relatively high civilisation which the European discoverers of South America found in the Highlands of Peru.

While the geographical conditions were unfavourable to the rapid advance of the native races, the situation of the continent in tropical latitudes was equally unfavourable to its colonisation and development by Europeans. North America, with its great extension in temperate latitudes, made an admirable home for the most vigorous European races, who rapidly multiplied, and filled up the continent. South America, except in the south, was unsuited to Europeans, who confined their settlement to the coast, and did little to develop the interior.

Agriculture and Manufactures. Agriculture is confined to the margin of the continent. In the grasslands horses, cattle, mules, and sheep are bred in enormous numbers, sheep being found in the drier areas—such as Patagonia. Notice that while North America can consume much of the meat it raises, South America has not a sufficient population to do so; also that the difficulties of transport make the preparation of meat extract an important industry, as the value is high in proportion to bulk and the cost of transport. North America, with its excellent communications, adopts less wasteful methods of preserving meat. Hides are an important export from South America. In North America the manufacture of boots and shoes is very important in the towns east of the ranching prairies, but South America is too thinly peopled for manufactures.

In the tropical forest, rubber and other forest produce are collected, and sent down the Amazon. It is easy to see why lumbering has not become important. Felling a tree in the climate of the tropics is a very different matter from felling a tree during the bracing Canadian winter, even if suitable labour were abundant instead of scarce.

The last occupation to note is mining. Many parts of the Andes are rich in minerals, and the gold and silver mines in particular have been worked for centuries. In the east, both the Guiana and Brazilian Highlands are rich in gold, and the latter also produce fine diamonds. The more useful metals only wait for a population to exploit them. The alkaline deposits of the Atacama Desert of Chile are valuable fertilisers in great demand for agricultural purposes.

Races and Religion. The aboriginal races, pure and mixed with European blood, form the bulk of the population, which is estimated at 38,000,000. The Europeans are mainly of Spanish and Portuguese descent, the latter especially in Brazil. Negroes and coolies from India have been introduced for plantation work in the east. In recent years there has been a large influx of Germans into Southern Brazil, and of Italians into the Argentine. The predominant religion is Roman Catholic; the language and general mode of life Spanish or Portuguese.

Venezuela. Venezuela (600,000 sq. miles) consists of three distinct regions: (1) the mountains in the north-west, including the coastal regions bordering the Caribbean Sea; (2) the llanos or grasslands of the Orinoco; and (3) the Guiana Highlands in the south-east.

The climate is tropical in the lowlands, but in the mountains *tierra caliente, tierra templada*, and *tierra fria* are well-marked. Still higher in the west are the *paramos* - bleak, treeless pastures, which extend to the snow line. Cinchona is abundant in the higher forests, in the clearings of which are grown potatoes, pulses, and the hardier cereals. In the middle zone the forests contain magnificent tree ferns, and in the valleys and plateaux bananas, coffee, sugar, etc., are cultivated. In the lower or palm forests the most important crop is cacao. Much chocolate is made from local sugar and cacao. Merida is the chief centre in these western mountains.

The less lofty eastern Caribbean ranges do not rise above the forest line. Here are situated the principal inland towns - Caracas, the capital, and Valencia - both in the coffee-growing region, and the ports of La Guaira and Puerto Cabello. A difficult line crosses the coastal range from La Guaira to Caracas, zigzagging 25 miles and climbing 5,000 ft. to reach a town distant only about six miles as the crow flies. From the summit of the pass Caracas is seen, 3,000 ft. below, laid out, like all South American towns, in blocks with rectangular streets of low, one-storied, white, red-roofed houses, set among green sugar plantations, beyond which a parched plain stretches to the encircling mountains.

The llanos, with their vast herds of horses and cattle, have already been described. The forests and minerals, including gold, of the Guiana Highlands should one day become very valuable, and the Orinoco a great commercial highway. At present the chief town, Ciudad Bolivar, is a place of little importance.

The Guianas. Notice in the map how many rivers cross *British Guiana*, the largest being the Essequibo. For 20 miles inland the coast originally consisted of mangrove swamps, flooded at high tide. They were dyked and drained by the Dutch, and these reclaimed lands, in which sugar is the chief crop, are practically the only cultivated or inhabited part of the Colony. The highlands are rich in gold, as well as in forest produce, but cannot at present be developed, owing to difficulties of communication. The capital is Georgetown, on the Demerara River, where rum and molasses are made from local sugar.

Dutch Guiana (46,000 sq. miles), capital Paramaribo, is very similar in character. *French Guiana* (30,000 sq. miles) is little developed, and

is used as a penal station. The capital is St. Louis, or Cayenne.

Brazil. The United States of Brazil (3,300,000 sq. miles) is, roughly, as large as Canada, the United States, or Australia. Its potential wealth is enormous, but only the fringe of the country is yet developed. It is essentially a tropical land. Only the extreme south is really fitted for European settlement.

Brazil consists of the vast forested Amazon Lowland, in the equatorial hot wet belt, and of the Brazilian Highlands, a rugged region covered with forests or wide, open grasslands.

The forest region of the Amazon is almost unexplored, and very thinly peopled by Indian tribes. Rubber and other forest produce is collected and sent to the towns, especially to Manaos, but also to Obidos, Santarem, and others, all at the junction of river routes, whence it is forwarded to Para or Belem, the great rubber port. Some forest produce is also shipped from San Luiz, or Maranhão, and Ceara, or Fortaleza, both east of the Amazon estuary.

The agricultural regions of Brazil are along the east coast. Sugar, cotton, cacao, and tobacco are grown in the State of Pernambuco, in the north-east, and exported from the port of that name, and from Bahia or San Salvador, in the neighbouring State of Bahia. Gold and diamonds are abundant in the States of Bahia and Minas Geraes, where all minerals are widely distributed. The latter state is in the grazing zone. Some cotton and much coffee is grown in the State of São Paolo, the capital of which has the same name, and is exported from Santos. Some coal is worked in Rio Grande do Sul, where cattle raising is important.

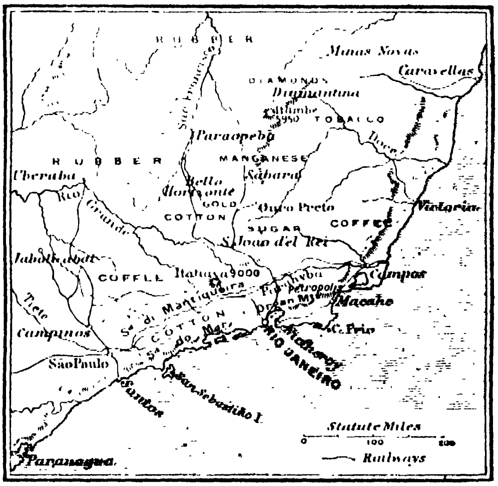
The Federal capital is Rio Janeiro [146], on a harbour of extraordinary beauty. The city, which has a bad reputation for health, is laid out, like most South American cities, on the chessboard plan.

Uruguay. Uruguay (72,000 sq. miles) is a savana land, lying east of the river Uruguay, which flows to the Plate Estuary. Its winters are warm, and the summer heat is tempered by the Atlantic. The chief occupation is the raising and slaughtering of cattle. The slaughtering centres are Montevideo, the capital, and Paysandu, where choice tongues are canned. Fray Bentos, south of Paysandu, makes meat extracts. Much of Uruguay is well suited for wheat growing, which will doubtless develop. The mineral wealth is considerable. Salto is the centre of the mining district.

Paraguay. Paraguay (140,000 sq. miles) lies between the Pilcomayo and the Parana, both joining the Paraguay, which bisects the country. There are magnificent forests in the hillier parts of the country. Much of Paraguay is well suited for agriculture. Yerba maté, or Paraguay tea, a native plant, which is in great demand throughout South America, is an important export. Cotton, indigo, and rubber also grow wild. Sugar, rice, tobacco, maize, coffee, and many fruits, can be cultivated. Cattle, horses, and sheep are bred. The capital is Asuncion, on the Paraguay.

Argentina. Argentina (1,800,000 sq. miles) largely consists of flat treeless pampas. In the west the country rises to the base of the Andes, where the climate is dry and many rivers end in salt lakes or swamps. The mountain streams make irrigation easy, and as this increases, much fertile land will be brought under cultivation. In the north, Argentina includes much of the forested Gran Chaco, which supplies valuable timber. Patagonia, in the south, is steppe or shingly desert in the east, but becomes wooded towards the Andes. The valleys are generally fertile under irrigation [147].

In the north of Argentina, the climate is tropical, and sugar, cotton, maize, tobacco, etc., are grown. In the pampas region, the climate becomes temperate. The seasons are warmer than in Canada, but in some respects the two countries may be compared. In both a great river opens out the country from the east, forming an outlet for the vast plains, where stock-raising and the cultivation of cereals is



146. THE HINDERLAND OF RIO JANEIRO

important. In a few years Argentina will compete with Canada as one of the great wheat lands of the world. Maize is also largely grown. As in Canada, the advance of settlement leads to the introduction of mixed farming, and the growth of dairy industries. After Australia Argentina is the chief sheep-farming country in the world, but Argentina wool is inferior to Australian.

Buenos Aires, on the Plate Estuary, the largest city in South America, has grown enormously in the last twenty years. Its miles of docks, spacious streets, handsome buildings, and scores of parks, make it one of the most imposing cities of the New World. Other important towns of Eastern Argentina are La Plata, the capital of the fertile state of Buenos Aires, south of the Plate Estuary, and Bahia Blanca, its southern port. On the Parana are Rosario, the second city in the country, to which the wheat ships can penetrate, Santa Fé, in a rich agricultural region, and Corrienates, in hotter zone, where subtropical crops can be grown.

In Central Argentina the land rises gradually to the west, in parts of which irrigation is necessary. The mineral wealth is considerable, but undeveloped. The chief towns are Cordoba, San Luiz, and Santiago.

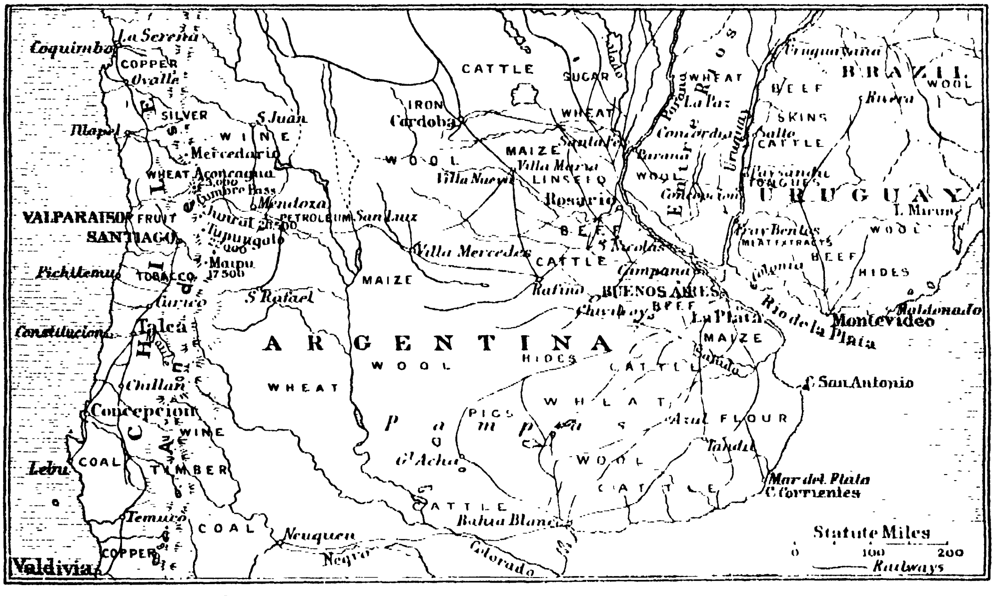
Western Argentina is as yet thinly peopled. In the north Tucuman is the centre of a sugar region. The cultivation of the vine is becoming important in the irrigated land at the base of the Andes. Salta and Mendoza are the chief towns of the vineyard districts. Stock-raising and mining are the other occupations. At present the cost of transport to the sea is very high, but this will diminish with the opening of the trans-Andean line to Chile.

Railways can be cheaply built in most parts of Argentina, owing to the flatness of the country. They now connect all the principal towns. The transcontinental line from Buenos Aires

irrigated ; (3) the fertile valley of Central Chile ; and (4) the colder, wetter south.

Northern Chile has rich deposits of nitrate of soda, but these occur at an elevation of 2,000 ft., in an absolutely desert region. All necessities of life, including water, must be transported at great expense, so that only the richest fields are worked, and there is no permanent population. The nitrate ports are Iquique and Antofagasta. From the latter a railway runs across the Andes to Lake Titicaca. Copper is abundant, but difficult to work. The mines are often in inaccessible regions of the Andes, and at an elevation where the rarefied air makes exertion fatiguing. The chief copper port is Coquimbo.

The fertile valley of Central Chile is the great centre of agriculture and population. All Mediterranean fruits and cereals can be grown south of 30 deg. S. The vine is largely cultivated for



147. THE MOST PROSPEROUS BELT OF SOUTH AMERICA

to Valparaiso, by Mendoza and the Cumbre Pass, is approaching completion, but a section has still [1906] to be done by mule.

The Falkland Islands. This group of two large and many small islands forms a British Crown Colony. The rugged surface consists of moorland, which forms good sheep pasture. The strong Atlantic gales make the islands destitute of trees. The only town is Port Stanley.

Chile. Chile (295,000 sq. miles) occupies the western slopes and valleys of the Andes south of 18 deg. S. Between 2,000 miles and 3,000 miles in length, it is only 100 miles wide, but communication across it is made difficult by the presence of the coastal range, which extends as far south as 40 deg. S. Owing to its great length from north to south, and its varied elevation, Chile has a great range of climate.

Chile consists of (1) a rainless northern region, the Atacama Desert ; (2) a dry zone, fertile where

wines and raisins. In the centre of the valley is Santiago, the capital, with a fine view of the snowy Andes. Its port, Valparaiso, destroyed by an earthquake in 1906, the great outlet for the valley, 55 miles distant, is reached by a railway 115 miles long, which has to climb the coastal range. Talca, Concepcion, and Valdivia are the other centres of the valley, where many small towns are growing up, each with its distilleries to turn out the cheap spirit—*aguardiente*—which is the curse of Chile. Coal is mined. Southern Chile is as yet thinly peopled. Both the mainland and the islands are densely forested, but as the timber cannot compete with that of Oregon or British Columbia, the process of clearing will be slow. Root crops do well, and the island of Chiloe claims with Peru to be the original home of the potato. Most North European crops can be grown except in the extreme south, which is too wet

for cereals to ripen. The mineral wealth is probably considerable. Some gold is worked. The port is Punta Arenas, on Magellan Strait. The island of Tierra del Fuego is partly Chilean, partly Argentine.

Peru. Peru (460,000 sq. miles) is north of Chile on the western and eastern slopes of the Andes. It consists of (1) a desert coastal region, fertile only where crossed by rivers from the Andes; (2) the sierra, or Andean region of mountains, valleys, and plateaux; and (3) the montana, or forested slopes of the Eastern Andes, sinking to the plains of the Amazon.

The coastal desert is fertile where it can be irrigated, producing sugar, cotton, cereals, lucerne, vines, and fruits. Lima, the capital, is separated by eight miles of desert from its port Callao. The line between them is continued over a pass 16,560 ft. to Oroya, whence it is continued to Cerro de Pasco, the silver town in the heart of the Andes. Arequipa, in Southern Peru, finely situated at the base of the volcano El Misti, is separated by 60 miles of desert from its port, Mollendo, the starting point of a line which climbs the Andes over a pass of 14,650 ft. to Lake Titicaca, on the Bolivian Plateau, 12,500 ft. above the sea.

The sierra region is about 250 miles wide, and contains many fertile plains and warm, sheltered valleys in which cereals and fruits can be cultivated. The domesticated alpaca and wild vicuña supply fine wool. The mineral wealth, especially in silver, is very great. In the lofty plains enclosed by still loftier mountains are many finely-situated towns, each surrounded by a fertile district. Puno, on Lake Titicaca, in the midst of a silver-mining region, is the terminus of the line from Mollendo, which is continued to Cuzco, 11,000 ft. above the sea, the old capital of the Incas or native rulers of Peru. The rich silver mines of Cerro de Pasco have already been mentioned.

The *montana*, or forest region, is drained by the tributaries of the Amazon. Cacao, coffee, etc., are grown in the ravines. The forests produce cinchona and rubber.

Bolivia. Bolivia (570,000 sq. miles) continues the sierra and montana regions of Peru. It consists of a lofty plateau in the west, and in the east of the forests of the Eastern Andes and the forests and savanas of the Upper Madeira and Pilcomayo basins.

On the plateau mining is still important, though the famous silver mines of Potosi are declining. Cattle are kept on the grasslands, and agriculture is important in the valleys. Cinchona and rubber are abundant in the forests of the Eastern Andes.

The capital, La Paz, on Lake Titicaca, is connected by a steamer service on the lake with Puno, and by the railways with the coast. It has a large trade in quinine and cacao, both collected from the Eastern Andes.

Ecuador. Ecuador (120,000 sq. miles) consists of (1) a coastal region which includes the rich valley of the Guayas with its cacao plantations, but becomes dry and barren towards the Peruvian frontier; (2) a sierra region, resembling that of Peru, with agriculture and cattle-raising as the chief occupations; and (3) the montana, or forest region, also resembling that of Peru.

On the coast the chief town is the important port of Guayaquil, at the mouth of the Guayas Valley. From Guayaquil a railway climbs to the Andean region, where the usual climatic and vegetation zones are distinguished. There are, as in Peru, many towns in lofty but cultivable basins surrounded by mountains. Of these the most important is Quito, the capital, 9,000 ft. above the sea in a fertile valley bordered by volcanic cones.

Colombia. Colombia (510,000 sq. miles) occupies the north-western angle of South America. The Colombian Andes broaden out into three chains exclusive of the coastal range, and between these are the valleys of the Atrato, Cauca, Magdalena, and of affluents of the Orinoco and Amazon. In addition to the Andean region, with the usual zones, Colombia thus includes the valleys of these rivers, that of the Cauca-Magdalena being the chief artery of a country where roads and railways hardly exist.

The usual range of products is found in the Andes, coffee being the most important. Large herds of cattle are kept in the llanos of the lower river valleys, and there is some mining. The largest town is Bogota, situated in the midst of a lofty savana or plateau of considerable extent (2,000 sq. miles). The ports on the Caribbean coast are Puerto Colombia or Sabanilla, and Cartagena. Barranquilla is the river prot of the Magdalena. Buenaventura is the only important place on the west coast.

Conclusion. Such, briefly surveyed, is our world. The year has brought its changes, startling or imperceptible. Earthquakes have laid great cities in ruins, but they will rise anew from their ashes. A new tunnel pierces the Alps, drawing north and south still a few miles nearer, new railways have been surveyed in many lands, new fields have borne their first harvest, new millions have been added to the future workers of the world. He who would be abreast of events must daily, with newspaper and atlas, note the changes, great or small, which each day brings. Each of these is at once cause and effect, the product of the past, and the parent of the future.

The next series of lessons in this course shows how man uses some of the world's varied products. Many volumes would not exhaust the subject, for man's ingenuity is as unlimited as the bounty of Nature. Each year's figures show the vast increase in the world's wealth, measured by its producing and purchasing power.

Our last thought, like our first, can hardly be other than one of reverence for the great physical laws which hold our world true in its course through space, and give seed-time and harvest in their season, and still more for the imperious law within man himself, which urges humanity onwards towards goals of which even the highest races are but faintly conscious.

Political Geography concluded; followed by
COMMERCIAL GEOGRAPHY

PRACTICAL BANKING

Scottish Banking. Loans and Deposits. Interest and Discount. Opinions and Sundry Functions. Banking Security. Head Office Work

By R. LAING

THE transmission of cash entails a certain loss, and the continued necessity for this in connection with an outlying branch bank in a new country might result in the ultimate closing of that office in consequence of the endless expense and risk. In this country these factors are, of course, very much modified, especially in Scotland, owing to the peculiar advantages which that country enjoys in her note issues.

Scottish Bank Notes. The banks in Scotland are ten in number, all of which are joint-stock companies possessing the right of issue. The amount which each is authorised to issue without security is fixed by the Act of 1845, being the average amount in circulation at that time. The authorised amounts can be (and are) exceeded by the banks against bullion held by the head office. One-pound notes are allowed and circulate largely, while the issues only lapse if they are voluntarily relinquished or if the bank becomes bankrupt. These privileges enable the banks to maintain the branches (numbering, at the close of 1905, 1,161), which are thickly scattered all over the country, and which are found even in the poorest and most sparsely populated localities. The Bank of England notes in the till of an English branch bank represent so much capital unemployed. The notes of a Scotch bank in its tills are nothing but its own I O U's. Until these are issued, the banks are not required to keep a single penny as reserve, which even then does not leave the head office. Again, while the expense in remittance of coin is heavy, it costs little to transmit £1 paper notes.

Scottish Banking. The actual banking business does not in any great degree differ from that in England. The cash credit (an advance made to a person of undoubted probity but of small means on the personal security of his friends, with an ulterior view to an increased note issue, which last, before 1845, cost the bank nothing) has, owing to the increase of individual wealth, lost its great importance; but the efficiency of the note exchanges, whereby a note, should it come into the hands of another bank, is at once returned to the issuer, is still a matter of which Scottish bankers can be justly proud.

The rise of Scotland to its present position from the semi-barbarism of two centuries ago is due in great measure to the note issues of her banks and to the wisdom with which they have been employed, and affords one of the most striking examples extant of a well-managed system of credit, forming, in the hands of an industrious people, the means of transition from poverty to wealth, and of laying the foundations of a lasting prosperity.

The forms in which deposit business is carried on in this country are three in number—deposit accounts and deposit receipts (bearing interest), and current accounts, on which no interest is allowed.

Current Accounts. If any person desire to deposit with a banker a sum of money which he wishes to be able to withdraw when he pleases, he will seek an interview with the latter on the subject. The banker, if the applicant is not already known to him as a person of respectability and integrity, will require some recommendation from a mutual acquaintance (this usually taking the form of a letter of introduction) in order that he may assure himself that the individual to whom he proposes to give the power of drawing upon him is not one who is likely to misuse such a privilege, and indirectly involve the bank's name in some disreputable transaction. A form may be signed by the customer agreeing to certain conditions, one of which may be that a minimum balance of a certain amount must at all times be kept. He will, in every case, fill up a slip showing the particulars of the sum paid in, and be given a cheque book (paying for the value of the penny stamps on the forms therein), and very probably a passbook, in which the sums received and the cheques paid are entered. The client may, however, prefer to have a statement of his account rendered to him periodically, and may take for each sum paid in an initialled duplicate paid-in slip or other receipt.

Should the client desire to remit an amount due by him to some correspondent, he can now, in place of obtaining a money order or bank draft, fill up a cheque form, converting it into an order on his banker for a certain amount, and remit it without further trouble to his creditor. The trouble and risk of paying in cash to his local creditors is also obviated by the use of his cheque book.

Deposit Accounts. If, however, the client is not in trade, and has few payments to make, he can have but little use for a current account, while he may have a large sum for which, at the moment, he cannot find use, and on which he desires to receive interest. In this case the amount will be placed in the deposit ledger and will bear a rate of interest varying with the Bank of England discount rate. A receipt may or may not be issued to the client at the same time.

The bank may, however, on receiving such deposits, grant receipts payable on demand, or at short notice, but keep no ledger account, the receipts being numbered consecutively, and their particulars being entered, when issued, in a

register kept for the purpose. An index is attached in which the numbers of the outstanding receipts are shown under the heading of each client. On a deposit receipt being presented for payment, this register is consulted, the particulars agreed, the date of payment entered in the column provided, the interest calculated, any sum to be withdrawn paid, and a new receipt issued for the balance. Such a receipt is never reissued, even although it has only been presented for the addition of interest due. The receipts outstanding may periodically be transferred in brief form to another register, a distinguishing mark being put against the original entry and the receipt marked off, when paid, in the second register.

Deposit Receipts for Fixed Periods. The practice of banks limiting their operations to this country is to confine themselves to receiving deposits at call or at short notice; but banks employing funds in the Colonies, or in foreign countries, obtain a large amount of deposits for fixed periods—say, of six months, or one, two, or more years. This money (which may be obtained through special agents) bears a high and uniform rate of interest. Interest is usually paid half-yearly, or at the termination of the deposit, income tax being deducted by the paying bank from all such interest, and accounted for by it to the Inland Revenue authorities. It is important in connection with the issue of all deposit receipts to fill in the year of issue in a sufficient number of forms at the beginning of a new year, to prevent the possibility of any loss occurring through a receipt being dated a year prior to the actual date of issue.

Overdrafts and Ledger Loans. If a customer of a bank exhausts the balance standing to his credit in the bank books, he may, after ascertaining that the banker is agreeable to such a course, continue to draw cheques, the payment of which leaves him in debt to the bank, the amount due varying from day to day. He is thereupon said to have *overdrawn* his account.

Instead of doing so, he may arrange with the banker for the loan of a certain sum for a definite period (usually against security), the amount of which is transferred to his current account to be drawn against in the same manner as if the actual cash had been deposited. The period for which the loan is granted may vary greatly, but will hardly ever exceed a year, a long outstanding inoperative loan being the particular aversion of any good banker.

The expiry of a loan provides an excellent opportunity for revising the conditions under which it is granted, or even of arranging for its repayment, to do which, in the case of a running overdraft, might be taken to imply, unless great tact be exercised, a want of confidence in the position of the client.

Bill Discounting. The discount of bills forms a third method of loan, possessing several distinct advantages. A banker can, if the bills in his case bear good names, count upon receiving their amounts at maturity without fail. A merchant, in accepting a bill, gives his undertaking to pay a specified sum on a certain day. He knows that he will be called upon to do so, and that any failure to honour his own may mean his commercial ruin. He therefore takes good care to provide for such liabilities, although he may regard the repayment of a loan with his banker very differently and, should the latter request this, look upon his action as an unwarranted affront, transferring, if he finds it possible, his custom to another institution. The facility of re-discount of bills with billbrokers is largely exercised by certain banks, who are thereby easily enabled to raise whatever sum they may at the moment require. The discount of bills on London enables provincial banks to provide themselves with an ultimate means of replenishing their London accounts, while it must not be forgotten that banker's discount exceeds somewhat the true discount of any bill, and that in consequence the return to the banker is greater than appears at first sight.

Calculation of Interest and Discount. The banker's discount on a bill is readily arrived at, being simply the interest on the full amount for the days it has still to run. The calculation of interest on fixed loans is equally easy, but the reckoning of that on an overdrawn account is a more difficult matter. The balance at the end of a day's transactions (shillings and pence over 10s. being taken as £1) is multiplied by the number of days for which it is current, and the result (which gives the days for which £1 would require to be lent to earn an equivalent amount of interest) is entered in a column provided for the purpose. At each change of rate, or at each half-yearly balance, this column is cast and the interest calculated by means of tables. In the case of deposit accounts (where the transactions are few), the interest on each balance current for any time being may be calculated separately.

The procedure detailed above cannot be adopted with deposit receipts bearing a varying rate of interest, for which another method is utilised. This is the valuation of the rate of interest due for each day in terms of a common basis of, say, 5 per cent.—a practice best explained by an actual instance.

In the book kept for the purpose the figure of 3630·2 may appear against December 31st, 1905. If the current rate is 2 per cent., the clerk will enter against January 1st, 1906, the figure 3630·6 (2 per cent. being ·4 of 5 per cent.), the interest on any receipt lodged on December 31st and paid on the following day being equal to ·4 of one day at 5 per cent. If on January 1st the rate is altered to $2\frac{1}{2}$ per cent., the figure 3631·1 will be entered against January 2nd. A receipt dated 2nd February, presented for payment on July 30th, if the figures for these dates are 3661·2 and 3720·1 respectively, bears 58·9 days' interest at 5 per cent.

Remittance Business. A very considerable portion of the banker's profits is derived from the commission which he charges for the collection of documents on other

towns, or for issuing, when requested, his draft on these places. The commission charged may vary greatly, and if the transactions between the two localities are limited, the means of transit few, and a balancing transaction hard to obtain, the charge made will be correspondingly high. An increase in the charge is in the nature of an insurance against the possibility of loss attending the banker's efforts to find someone with whom he can arrange a transaction to reimburse him or his correspondent.

Sometimes, however, the banker's charges include an insurance against possible loss through failure on the part of his client. He may be asked by a client to accept bills drawn upon him on account of the latter, and if he is satisfied with the business and the security offered in connection with it, he will do so on his commission being paid. Similarly, he may endorse bills for his customers, for a consideration. The object of his acceptance or endorsement is to allow of the bills being discounted or sold by the holders to the best advantage.

It is a very common custom for the clients of a country bank or branch to make their bills payable at the office of the bank's London office or correspondent, in order to facilitate their discount. These will be retired by the London office on receipt of advice from the country banker, a certain charge being made by the latter for the trouble given. A varying charge may be made either yearly or half-yearly on those current accounts which do not show a sufficient running balance to compensate the banker for the work attendant thereon.

Securities and Periodical Payments. The banker invariably undertakes the custody of any securities deposited with him by his clients free of charge, and will also attend to the collection (either with or without charge) of coupons attached to the relative bonds. Due care must be taken to register in diary form the dates on which these coupons fall due, in order that, some little time beforehand, they may be cut from the sheets and forwarded for collection or sale, as the case may be. If the coupons are payable in a foreign country, they will be sent to the London correspondent either for collection or sale (in the latter case the coupons being bought by some dealer in exchange as if they were bills); but those payable in this country will be remitted for collection to the place of payment. Income tax on all coupons is deducted and paid by the banks to Government, forms provided by the Inland Revenue authorities being, in the event of the client wishing to reclaim the amount, completed, signed, and handed to him.

The sale and purchase of securities may be attended to by the banker on behalf of clients who have securities deposited with him, either for safe custody or in security of loans. The business is a profitable one in consequence of the return commission allowed by the stockbroker.

The banker will also undertake to see to the payment of club subscriptions, insurance premiums, pensions and allowances, in accordance with instructions received from his clients. In this connection it is necessary to exercise great care lest any payment is made after the relative instructions have been cancelled. The card system can be advantageously used in connection with such payments. The particulars of the payment and of the authority are entered on the face of the card (the dates of the payments made being detailed on the back), and the cards sorted into a case or file in the order of payment. After the payment has been made, the card is replaced in accordance with the date of the next payment. The system provides at the same time a diary of future and a record of past payments, but requires the exercise of great care, as the accidental misplacement or destruction of a card is attended with serious consequences. [See BUSINESS MANAGEMENT.]

Opinions. The card system is widely adopted in connection with the record of opinions and reports on parties received, although a system of indexed books may be used. The convenience of alphabetical arrangement is very great, but the defects which are referred to above always hold good. While receiving opinions from others the banker will be called upon to give many. In furnishing written reports, he will be careful to use the form provided, which states that the information given is without responsibility. Some banks make, in addition, a practice of supplying such information on unsigned memorandums. The usual form of inquiry asks if the individual is of good standing and respectability, and if he may be considered good for a stated amount, either in the ordinary course of business, as a guarantor, or so forth, according to the nature of the transaction. The banker in his reply will, as far as possible, confine himself to stating whether or not, in his opinion, the name is good for the amount mentioned. He will not, except for a good reason, volunteer any data, while a negative reply should be worded with special care, as, if it can be shown that his client's credit has suffered thereby, he may be liable for damages. Whenever possible the opinion will be given verbally.

Correspondence. The rule regarding the wording of an unfavourable report applies with equal force to correspondence which deals with the refusal of business or similar transactions. The banker will refrain from explanation of the reasons for his decision, which, if unfavourable, should be simply conveyed in a polite expression of regret. In general, the banker will confine himself strictly to the subject-matter of correspondence, and leave any question of policy which does not affect his interests to the decision of his client. No gratuitous responsibility should be undertaken in the matter of giving advice, especially with regard to the buying and selling of securities. If, however, the banker for any reason gives his opinion, he will invariably advise the adoption of the safest course. The foregoing applies with equal force to verbal communications.

Miscellaneous Functions. An important function is the issue by the banker of Bank Credits without recourse, Travellers' Letters of Credit and Circular Notes. The first are issued by the banker on account of his clients (who give what security is deemed requisite) in favour of the merchants with whom these clients deal, or perhaps the bankers of these merchants. The bank issuing the credit undertakes that if the stipulated conditions are adhered to it will accept and pay the relative bills. In this manner the purchaser is enabled to obtain an extended credit, while the seller receives a cash settlement of his debt. The banker is not entitled to cancel any such credit once issued, except with the agreement of the party in whose favour it is drawn. If, for a very particular reason, the banker does cancel any such credit, a sufficient indemnity to cover possible damages will be obtained. Travellers' Letters of Credit, which bear the signature of the individual in whose favour they are drawn, operate as an authority to the correspondents named therein to cash to the person designated his drafts on the issuing bank for the sum mentioned, the amounts so paid being marked on the back of the credit by the paying bank. If, however, the client desires it, he can obtain a supply of Circular Notes (practically credits for £10 and similar amounts), which will be cashed by the correspondents on his endorsing them, provided he produces a Letter of Indication, giving his signature, and containing the names of the paying correspondents.

The payments of dividends, coupons, etc., may be undertaken with or without charge (the documents being, perhaps, checked off against lists furnished by the company in question), the bank on occasion dealing with the receipt of application money, calls in connection with company promotions, and the return of any sums not accepted. The clerical labour involved in addressing envelopes, filling up forms, etc., in the case of a large and successful issue is very great indeed, but the work is more monotonous than intricate.

Shares and Similar Securities. All banking business is contrived with a view to the exclusion of any element of speculation, a point that exercises an important effect on the securities which will be accepted in cover of a banking advance. The more easily realisable the security is at all times, the fewer the responsibilities attached and the less risk there is of depreciation, the greater the attraction it will have in the eyes of a bank. Share certificates, with a transfer form attached, either completed in every respect or bearing only the signature of the shareholder, are largely taken; but, for various reasons, registration of the shares into the names of the bank's nominees (usually two of its principal officers) is preferable. Securities which do not possess a market quotation or which bear an uncalled liability are not taken. Bearer bonds of a good class become an excellent banking security on a pledge form being signed. The bank's own shares may form the cover for an advance to one of its shareholders.

Bills lodged for collection bearing good names, or assignations of insurance policies (although the amount of the surrender value may be small and the present value of security therefore not of great amount), are also acceptable, while documents of title relating to merchandise are largely dealt with in certain localities. In these, however, the element of depreciation may be very great, and, in addition, the banker must be thoroughly assured of the good faith of his client, so largely is he dependent on the honesty of the latter's declarations as to the quality of the goods, and sometimes even as to their quantity. The banker will, in connection with such securities, see that insurance is taken out and renewed. The actual ownership of land, houses, and ships is not desirable as security, in consequence of the multifarious liabilities and responsibilities attached to these; and a mortgage bond, or similar document over the property in question will, instead, be made out, giving the bank full power over the property but protecting it from any trouble in the matter. Even in this form, however, the security is not looked upon with great favour, owing to the possibility of an ultimate sale proving difficult.

Personal Securities. The simplest form for personal security is that of a promissory note signed by the debtor and the guarantor, coupled with a letter stating that it is to be held in security of a certain debt. The object of the letter is to connect the debt and the security, rendering the granters of the note only liable for the actual amount of the loan. The note, being made payable one day after date remains operative for six years, when the special prescription applying to bills terminates the obligation.

Guarantees form a more formal and complex form of personal security. Each bank will possess a stock of forms suited for its varying business, while the exact terms used by the different institutions vary somewhat in their wording. The form chosen for any particular case must be carefully perused to see that it covers all possible contingencies in the proposed business.

If a time limit is inserted, and the guarantee is not renewed, or if a guarantee is terminated by notice being given by the guarantor, operations on the accounts must be stopped and no payments in reduction of the debt allowed, should it be decided not to release the guarantor. Any sums paid into such accounts will be held to liquidate the debt, while amounts paid out create a debt which is not covered by the guarantee—*i.e.*, if the guarantor of an overdraft for £4,500 terminates his guarantee, he is absolved from liability if, after he has done so, the banker allows the debtor to pay in amounts totalling £4,500, even although a similar sum is concurrently withdrawn. In the event of a loan covered by personal security being utilised to the full extent, interest is not debited to the account if the client is not considered good for the amount. A surety for £200 and interest may be liable for an amount of interest greatly exceeding the principal sum, provided it is shown in the bank's books in this category; but the moment it is added to the debt and becomes principal, his

responsibility for it ceases, and he is only liable for £200, and any interest on this sum not applied.

Security Forms and Banking Law. The printed forms kept in stock will usually cover all the commoner methods of business, those relative to any special transactions being prepared either by the legal department of the bank or by its solicitors. The wording adopted may be altered from time to time in consequence of some legal decision, or of some question arising in the ordinary course of business. The documents may, according to individual practice, or the nature of the transaction, be either completed by the branch officials or by those at the Head Office.

The law connected with the business of banking comprises a fairly large section.

The Bills of Exchange Act is at once the largest and most essential part of Banking Law, but the ordinary legal knowledge (added to if possible) regarding trusts, agency, lien, securities, bankruptcy, debt, and common law should be possessed by the banker. It is not possible to deal with such a list here, and, indeed, such knowledge, although very desirable, is not absolutely essential, the procedure to be adopted in any particular case being usually laid down in some manner for the guidance of officials. It is only necessary to emphasise the point that the student should make himself, as far as possible, acquainted with the intention of each point of law, and, if possible, the history which led to its enactment.

In some institutions a book of regulations in which the duties of officials, the branch routine and returns, and the more essential points of banking law are dealt with more or less fully, is supplied to each branch. From time to time circulars are issued, which, although mainly referring to rates, official appointments, etc., also deal with any important matter which may have arisen, and with the contents of these, together with the book referred to, each official is expected to make himself familiar.

Documentary Bills. Bills of Exchange are known as *documentary bills* when documents of title to some security against which the bill is issued are attached to the draft; bills unaccompanied by such papers being termed "clean." They almost invariably take the form of invoices, bills of lading, and insurance policies for a shipment of goods, although a large amount of scrip bills (drafts with share certificates and signed transfers attached) are drawn. Certificates of Origin, or Consular Certificates, may be included in the shipping documents, if necessary, in consequence of the fiscal arrangements of the country exported to. On entering into such business, a *letter of hypothecation* is signed by the client, allowing the banker to deal with the goods relating to any bill as he may deem desirable. In the ordinary course of business, however, the banker will consult the wishes of his client before taking any steps in this direction, only exercising his right in some emergency—say, the bankruptcy of his customer. In addition to examining the bill itself the documents require scrutiny. The invoice amount should cover the bill, and the packages referred to in it appear on the bill of lading; while it is essential that the whole of the signed copies of the last, together with an insurance policy covering the amount in question, be received. The possession by an unscrupulous individual of a copy of the bill of lading may, through his obtaining delivery of the goods, deprive the banker of his security, while the same result will be arrived at through the loss of a shipment not covered by insurance. If the goods remain in the hands of the receiving banker for any length of time he will require to see that they are properly warehoused and covered by fire insurance from the date the marine insurance expires to the payment of the bill.

Documentary bills are either "D A" or "D P" drafts. In the former case the drawee obtains, on accepting the bill, the documents attached, but in the latter he must take up the draft under rebate (pay the bill amount less an allowance) if he desires the documents in order to obtain the goods. As the rebate allowed is small, there is little object in rebating a "D/A," or "clean" bill, if any other use can be found for the money.

Head Office Work. The work at the head office, which is distinct from the ordinary branch business, divides itself into several sections. Auditing the branch returns dealing with the book entries will occupy the attention of a large staff, whose duties in some respects are hardly agreeable. The comparison weekly of thousands of entries between, perhaps, a hundred or more branches, with the certain knowledge that to pass an error means the repetition of the monotonous task, is not a fascinating prospect. In this department the weekly statements combining the branch returns will be made up. The returns, apart from those just referred to, will probably be dealt with by what is usually termed the Inspection Department. In addition to the supervision and record of the loan business at the branches, the work in connection with the bank's staff and their movements will be undertaken here, while periodically one or more officials will be despatched from this department to some branch to check the cash and securities on hand, agree with the books the balances of the various accounts, test the accuracy of the bookkeeping in various ways, judge of the fitness of the branch staff and of the suitability of the branch premises, and look thoroughly into all sums lent by the branch. The stationery supply will call for the attention of one or more officials, while the legal department has already been referred to.

Continued

ELECTRICAL ENGINEERS

Training in Workshops and in Technical Schools. Mechanical Basis of Engineering. Books on Electrical Engineering

By Professor SILVANUS P. THOMPSON

LIKE every other branch of engineering, electrical engineering, whether viewed as an industry or as a profession, requires of those who would follow it with success a double preparation. For, since its whole existence lies in the application of science to industry, success in its pursuit depends on the mastery both of the science which lies at the bottom of it all and of the practical methods in which that science is applied.

Practical and Theoretical Aspects. The common way of expressing the two aspects of the subject by dividing them into theoretical and practical is not a very adequate classification, because a great part of that which is truly theoretical is to be mastered only by practical studies in the laboratory or in the testing-room, while much of the practical part of engineering, whether electrical or mechanical, is to be mastered not at the bench or the forge, but in the drawing office. Neither is it adequate to divide the training of the electrical engineer into technical and commercial, though both enter into that training, for part of the training of an engineer is to teach him how to reckon out the cost of production, and this is a highly technical study, though it sounds commercial enough.

But if it is not easy to define in terms the two divisions or aspects of the training, all authorities are agreed on the necessity of a double training, without which the making of an engineer of any kind is incomplete.

A Mechanical Basis. Electrical engineering has much in common with mechanical engineering. Indeed, it has been said—though perhaps it is slightly overstated—that nine-tenths of the work of the electrical engineer is mechanical engineering, and only one-tenth electrical. But it is quite certain that a mere study of electricity will never make a man into an electrical engineer. It may make him into an electrician, and good electricians are always needed in the world, though the field for them is more limited. So far as constructive electrical work is concerned, a thorough engineering basis is required. For, in truth, the factory work of the constructive electrical engineer is very much the same as that of the mechanical engineer. Suppose that he has to construct dynamos or electric motors. The machines must first be designed, and all the necessary drawings worked out in the drawing office. Some of these drawings then go to the pattern-shop, in order that the wooden patterns may be made for the frames, bedplates, and other parts that are to be cast. When the patterns are completed, they must go to the foundry to be moulded, and the castings made, in cast iron, cast steel, or brass. Other drawings go to the forge in order that the necessary forgings may be produced. When the forgings and castings are ready, they go to the machine shops to be machined, turned, bored, milled, chipped, or filed by the machinists, turners, and fitters. Other parts have to be stamped out. Bolts, screws, keys, nuts, and rivets must be made to hold the parts together. Then the parts must be assembled by fitters, and the machines erected and tested. So far all these processes are just the same as are necessary in constructing steam engines, sewing machines, or pumps. It is purely mechanical engineering. But there are also electrical parts to be made. The magnet bobbins have to be wound with copper wire coils. The armature windings must be made and properly insulated. Commutators have to be built of copper and mica and mounted in appropriate shells. For this part a knowledge of electrical conduction and of insulation is necessary. But it is clear that a majority of the constructional processes are mechanical. One might say the same about the manufacture of arc lamps, of switch gear, of telegraph instruments, and, indeed, of all electric instruments and appliances.

The Double Training. The two essential parts of the necessary training are distinguished according as they are to be acquired:—

(1) In the shops or factory;
(2) In the technical school or college.

Neither the factory alone nor the technical school alone can afford a complete training for the engineer, whether mechanical or electrical. The youth who is trained only in the technical school or college is not in general fitted to become anything better than an engineer's clerk or a testing assistant. He lacks the knowledge of practical construction. The youth who is trained only in the shops or factory is not likely to rise above the grade of a fitter or a draughtsman; he lacks the grasp of principles, and has not been trained to exact calculation. In these days of competition the engineer must be trained to think, and not merely to think, but to think in terms of exact and calculable quantities. He must be taught systematically how engineering thinking is done, how formulæ enter into calculations and estimates, and how the formulæ themselves are founded on scientific principles, and how they have to be modified to meet special cases. Mathematics is the art of thinking in exact quantities, and of managing the symbols by which such quantities are represented. Hence mathematics is an absolute essential to all real engineers. Electrical engineers require additional mathematical formulæ to enable them to work out electrical problems.

But engineers must also be trained to work, and to work with precision; they must learn to

work in wood, and iron, and steel, and brass. This training they can acquire only by working. Otherwise they will not really know how engineering work is executed. All mechanical engineers ought also to know how engineering work is designed, and how it is tested; and for this purpose they need to be trained in the testing laboratory, where they learn about the strength of materials, and in the laboratory of applied mechanics, where they learn by systematic experiment the application of abstract rules to actual mechanism. Further, electrical engineers must learn in the electrical laboratory, by experimenting with their own hands, the measurement of electrical quantities, the testing of the electrical properties of materials, and the performance of electrical machinery.

Which Kind of Training First? The question most often asked by parents and guardians of the youth who wants to become an engineer is this: Should he go to the works before he attends the technical college, or should he go to the technical college before he enters the engineering works? To this question there is no one answer; the answer must depend on the temperament of the youth, and on the circumstances of the case. There are always plenty of exceptions to any rule. But for the boy of average abilities and ordinary circumstances, the course which experience has shown to be best, in the opinion of those able to judge, has been very clearly laid down by unmistakable authority.

The Educational Report. In April, 1906, there was issued a report by a committee of experts representing the Institutions of Civil, Mechanical and Electrical Engineers, presided over by Sir William White. After taking evidence of over 260 leading engineers and teachers of engineering they agree with very considerable unanimity in the following conclusions:

1. The average boy should leave school at about 17 years of age—much depends on individual development—but should not be under 16 nor over 18.

2. If possible a preliminary stage of practical training in the mechanical engineering shops, of about one year, should precede college training. In some cases this introductory workshop course might be taken after the first year at college.

3. From the first, during workshop training, the youths should be paid regular wages, and keep regular working hours.

4. Evening study might impose too severe a strain on health. Therefore, since it is most important that school studies, particularly mathematics, should not be too soon forgotten, the introductory workshop course should not exceed one year; but in exceptional cases where a practical training of three years or so precedes a college course there must be some systematic tuition, in evening classes or otherwise, to prevent studies from being forgotten.

5. The period of college training for the average boy should be three years. Of the replies received, 73 per cent. say two or three years, while 71 per cent. say three or four years.

6. A sound and extensive knowledge of mathematics is necessary. This, of course, implies that the colleges should require the youths to pass an entrance examination to show that they have at least as much mathematical training as is required, say, in the Matriculation Examination of the London University. Engineers need training in trigonometry, solid geometry, differential and integral calculus. It may be noted that in Germany students are not even admitted to the Polytechnics who cannot begin the calculus.

7. The committee recommend strongly efficient instruction in engineering drawing.

8. After the college training, the youths should have at least three more years of practical training in the shops, part of this being in the drawing office, and the wages paid them after leaving college should be somewhat higher, especially in the later years.

No Premiums. The report of the committee gives no sanction to the pernicious practice of requiring premiums. Premiums are never paid in America or in Germany; in England the survival of the premium system is a curse to the industry

The committee is silent as to the proper organisation of the training in factories, where unfortunately the foremen are often violently prejudiced against teaching the young hands anything, and are not paid to teach them. This is a weak spot in the training of engineers.

Other Plans. In Glasgow and Edinburgh the plan is adopted of teaching the youths in the college during the six winter months, and of drafting them into the factories during the six summer months. In Sunderland the engineering employers have agreed to a similar plan; but in most parts of England the employers do not fall in with this plan.

For the training of engineering workmen, including electrical workmen, the old plan of apprenticeship still exists, boys leaving school at 14 years of age and working in the factories with small wages until 20 or 21. For such youths, the training afforded in evening classes is of service; but few can, without detriment to health, give more than two nights a week, and the training can, therefore, never be thorough.

Posts as switchboard attendants in electric lighting stations do not afford much scope for real training.

There is a small demand for specially trained electro-chemists; and for all electricians a knowledge of elementary chemistry, such as may be acquired in the laboratory of any of the technical schools, is most useful.

Degrees in engineering are a luxury. Few engineering firms attach the slightest importance to them; the training at a first-rate technical school is esteemed far more than a university degree. For those who want to become teachers of engineering, university degrees are, however, of great value in seeking an appointment.

THE BEST BOOKS ON ELECTRICAL ENGINEERING

There will always be a number of earnest young engineers who have not the opportunity of taking out a college course. Also those who have been trained in a technical college will always want to know what are the best sources of information in the different branches of the subject. So wide a subject as electrical engineering cannot possibly be contained in any one textbook. In fact, the young engineer cannot be expected to buy all the books to which he should refer, and with which he should be familiar. Books of reference, to be consulted in the public libraries or in the libraries of the technical institutes, are to be recommended rather than textbooks which pretend to serve up the whole subject in one volume. For the sake of those who desire further guidance in such reading a list of standard works is here appended. It is confined to books in the English language, and therefore does not include some of the very best and most useful of treatises, which are printed in German.

ELECTRICAL LABORATORY WORK. "Practical Electricity," by Ayrton (Cassell, 7s. 6d.); "Electrical Laboratory Notes and Forms," by Fleming ("Electrician," 7s. 6d.); "Handbook of Electric Testing," by Kempe (Spon, 18s.); "Practical Measurement of Electrical Resistance," by Price (Clarendon Press, 14s.).

BATTERIES. "Primary Batteries, Their Construction and Use," by Cooper ("Electrician," 10s. 6d.).

ACCUMULATORS. "Secondary Batteries, Their Manufacture and Use," by Wade ("Electrician," 10s. 6d.); "Management of Accumulators," by Sir D. Salomons (Whittaker, 5s.).

ARC LAMPS. "Electric Lamps and Electric Lighting," by Fleming ("Electrician," 6s.); "The Electric Arc," by Mrs. Ayrton ("Electrician," 12s. 6d.); "Electric Lighting," by Swinton (Lockwood, 1s. 6d.).

GLOW LAMPS. "Electric Lamps and Electric Lighting," by Fleming ("Electrician," 6s.); "The Incandescent Lamp and its Manufacture," by Ram ("Electrician," 7s. 6d.).

DYNAMOS AND MOTORS. "Armature Windings," by Parshall and Hobart (Blackwell, 30s.); "Dynamo-electric Machinery," 2 vols., by S. P. Thompson (Spon, 30s. per vol.); "Dynamo Design," by Hobart (Whittaker, 7s. 6d.); "Dynamo Attendants and their Dynamos," by Broadbent (Rentell, 1s. 6d.); "Diseases of Electric Machinery," by Schultz (Spon, 3s. 6d.); "The Dynamo," by Hawkins and Wallis (Whittaker, 15s.); "Electric Generators," by Parshall and Hobart ("Engineering," 31s. 6d.); "Original Papers on Dynamo Machinery," by Hopkinson (Whittaker, 5s.).

MAGNETISM. "Magnetic Induction in Iron and Other Metals," by Ewing ("Electrician," 10s. 6d.); "The Electromagnet and Electromagnetic Mechanism," by S. P. Thompson (Spon, 15s.).

WIRELESS TELEGRAPHY. "Signalling Across Space Without Wires," by Sir Oliver Lodge ("Electrician," 5s.); "Electric Wave Telegraphy," by Fleming (Longmans, 24s.).

ELECTRIC HOUSE WIRING. "Electric Wiring Tables," by Maycock (Whittaker, 3s. 6d.); "Electric Wiring," by Clinton (J. Murray, 1s. 6d.); "Electric Wiring and Fitting," by Drysdale (R. J. Bush, 3s.); "Practical Electric Light Fitting," by Allsop (Whittaker, 5s.).

ELECTRO-CHEMISTRY. "Elements of Electro-chemistry," by Lüpke (Grevel, 7s. 6d.); "Treatise on Electro-metallurgy," by McMillan (Griffin, 10s. 6d.); "The Electric Furnace," by Moissan (Arnold, 10s. 6d.); "Electric Furnaces and their Industrial Application," by Wright (McGraw, New York, $3).

GENERAL ELECTRICITY. "The Electrician Primers," 3 vols. ("Electrician," vol. 1, 3s. 6d.; vol. 2, 6s.; vol. 3, 4s. 6d.); "The Electric Current," by Walmsley (Cassell, 10s. 6d.); "Elementary Lessons in Electricity and Magnetism," by S. P. Thompson (Macmillan, 4s. 6d.); "Experimental Researches in Electricity," 3 vols., by Faraday (Quaritch, 48s.).

PHOTOMETRY. "Industrial Photometry," by Palaz (Sampson Low, 12s. 6d.); "The Art of Illumination," by Bell (Constable, 10s. 6d.).

TRAMWAY MOTORS AND TRACTION. "Modern Electric Railway Motors," by Hanchett (Street Railway Publishing Co., New York, $2); "Electric Traction," by Rider (Whittaker, 10s. 6d.); "Electric Street Railways," by Houston and Kennelly ("Electrical World," New York, $1).

ELECTRIC RAILWAYS. "Electric Railways and Tramways," by Dawson ("Engineering," 42s.).

ALTERNATING CURRENTS. "Alternate Current Working," by Hay (Biggs, 5s.); "Notes on Alternate Currents," by Simmons (Cassell, 1s.); "Alternating Currents of Electricity," by Still (Whittaker, 5s.); "Alternating Currents of Electricity," by Lamb (Arnold, 10s. 6d.).

TRANSFORMERS. "Transformers for Single and Multiphase Currents," by Kapp (Whittaker, 6s.); "The Alternate Current Transformer," 2 vols., by Fleming ("Electrician," 12s. 6d. per vol.).

POLYPHASE CURRENTS. "Polyphase Electric Currents," by S. P. Thompson (Spon, 21s.); "Polyphase Currents," by Still (Whittaker, 6s.).

CENTRAL ELECTRIC STATIONS. "Central Electric Stations," by Wordingham (Griffin, 24s.); "Central Station Electricity-Supply," by Gay and Yeaman (Whittaker, 10s. 6d.).

ELECTROPLATING AND ELECTROTYPING, ETC. "Electro-deposition of Metals," by Langbein (Baird, Philadelphia, $4); "Electro-metallurgy Practically Treated," by Watt (Lockwood, 4s.).

ELECTRIC INSTRUMENTS, ETC. "Induction Coil in Practical Work," by Wright (Macmillan, 4s.); "The Potentiometer," by Fisher ("Electrician," 6s.); "Electrical Influence Machines," by J. Gray (Whittaker, 5s.).

ELECTRIC BELLS. "Electric Bell Construction," by Allsop (Spon, 3s. 6d.).

ELECTRICAL THEORY. "Absolute Measurements in Electricity and Magnetism," by Gray (Macmillan, 5s. 6d.); "Treatise on Electricity and Magnetism," 2 vols., by Maxwell (Clarendon Press, 32s.); "Recent Researches in Electricity and Magnetism," by J. J. Thomson (Clarendon Press, 18s. 6d.); "Elements of the Mathematical Theory of Electricity and Magnetism," by J. J. Thomson (Cambridge Press, 10s.), and "Conductivity of Electricity through Gases," by J. J. Thomson (Cambridge Press, 16s.); "Electromagnetic Theory," 2 vols., by Heaviside ("Electrician," 12s. 6d. per vol.); "Electric Waves," by Hertz (Macmillan, 10s.); "Theoretical Elements of Electrical Engineering," by Steinmetz (Whittaker, 12s. 6d.); "The Electronic Theory of Electricity," by Fleming ("Electrician," 1s. 6d.).

ELECTRIC TRANSMISSION OF POWER. "Electric Transmission of Energy," by Kapp (Whittaker, 10s. 6d.); "Electric Power Transmission," by Bell (Whittaker, 15s.).

ELECTRICITY METERS. "Electricity Meters," by Solomon (Griffin, 16s.); "Electricity Meters," by Gherhardi ("Electrician," 9s.); "American Meter Practice," by Reed (Spon, 8s. 6d.).

Electricity concluded; followed by TELEGRAPHS

THE LANDSCAPE PAINTERS

The Old Masters' Landscapes. Wilson and Constable. The Barbizon School. Turner the Sun Worshipper. Impressionism. Japanese Influences

continued from page 4120

By P. G. KONODY

Of all the arts, that of landscape painting is the most modern. It belongs, more than any other, to our own time, though its beginnings can be traced back to the days when Giotto delivered the art of painting from Byzantine formalism, which had no eyes for the beauties of Nature. Indeed, the replacing of the flat gold backgrounds of Byzantine art by the naïve landscape setting of Giotto and his followers is the first link in that long chain of evolution which leads to the discovery of atmosphere and sunlight by Constable, Turner, and the Impressionists. The Giottesques, and all the Italians, even Perugino and Raphael, and in the North the Van Eycks, Memling, and all the other Primitives, never painted landscape for its own sake. In their pictures it is always entirely subordinate to the figures, and used either to fill an empty space in a pleasing manner or to enhance and accentuate the sentiment expressed by the figures.

The First Painter of Landscape. Landscape, painted for sheer love of Nature, and for its own sake, did not appear before the seventeenth century, though a near approach to it was made by the Venetians Giorgione and Titian, and in the North, at an even earlier period, by J. Patinir (A.D. 1490–1550). The beautiful scenes from the Cadore country, which form the background of many of Titian's pictures, speak at least of his love for the picturesque district in which he was born and had passed his childhood, and there is at the Pitti Palace at least one drawing from his pen in which the fine scene in the Cadore is rendered for its own sake, without the addition of figures. Patinir took an obvious delight in the careful objective rendering of landscape, to which the figures that enact the scenes of sacred history are mere accessories; but his view, like that of "Velvet" Breughel (A.D. 1569–1625), who devoted himself to fantastic scenes of Paradise, with minutely executed flowers and animals, was purely objective—that is to say, impersonal and unemotional, and his colour limited to a conventional scheme.

The Classical Landscape. Nicolas Poussin, Rubens, and Claude Lorrain were the first real landscape painters, though one of them, Rubens, touched upon landscape only passingly, to show, as it were, that his genius could cope with every problem that came within the painter's field. The few landscapes he has left us have the same verve and vigorous, swinging brushwork as his figure subjects and great compositions, and range from the heroic and dramatic to the simple and rural. Nicolas Poussin had grown up in the classic atmosphere, and was steeped in the study of the antique and the Italian masters. At the same time he was a close observer of tree and cloud forms, the mastery of which enabled him to rearrange and combine them into formal compositions of arcadian scenes, in which figures and setting were at least co-ordinate in importance. He never rose above a convention which was the very negation of naturalism, and used Nature only as a source whence he drew the motifs for his pictorial inventions. His colour was as cold and formal as his design. He was the father of the classical or heroic landscape.

The Discoverer of Sunlight. With Claude Lorrain (A.D. 1600–1682) figures ceased to be of any importance, and sunlight with its varying effects first became the real subject of the picture, though even Lorrain did not consider Nature unadorned to be worthy of pictorial representation, and continued, like his precursors Nicolas and Gaspard Poussin, to weave its details into well-ordered combinations, from which classic ruins, temples, and columns were never allowed to be absent (83). But with him trees and clouds and winding rivers ceased to be mere forms conventionally coloured. He noted the play of light and shade on these objects, and expressed in masterly fashion the different times of the day—the glow of sunset and the restful coolness of early morning. About two centuries later, his noble compositions were to become the starting-point for the greatest master of modern landscape—for Turner. Equally subjective in his view of Nature was Lorrain's Italian contemporary, Salvator Rosa, who depicted the romantic and turbulent aspect of landscape in the rugged ravines and wind-tossed trees that form the background for his scenes of strife.

Dutch Temperament. It was left to the seventeenth century Dutchmen, Ruysdael, Hobbema, and Cuyp, to establish the claims of landscape as a genre independent of figure painting. Whilst Ruysdael, in following the successful Allaert von Everdingen, sought for the picturesque in Nature, and found it in the wild rocks and seething mountain streams and waterfalls of a country he probably knew only through the work of his popular contemporary, Hobbema was the sympathetic painter of his own country, which he rendered with intimate simplicity, setting down things as he found them, in all their quiet homeliness. But neither Ruysdael, nor Hobbema, nor even the great Rembrandt, who brought the whole passionate intensity of his temperament into his landscapes, could realise entirely the colour of Nature and free their palette of the browns demanded by a time-honoured convention for the painting of

85. THE POND, BY COROT (Louvre, Paris) *Mansell*

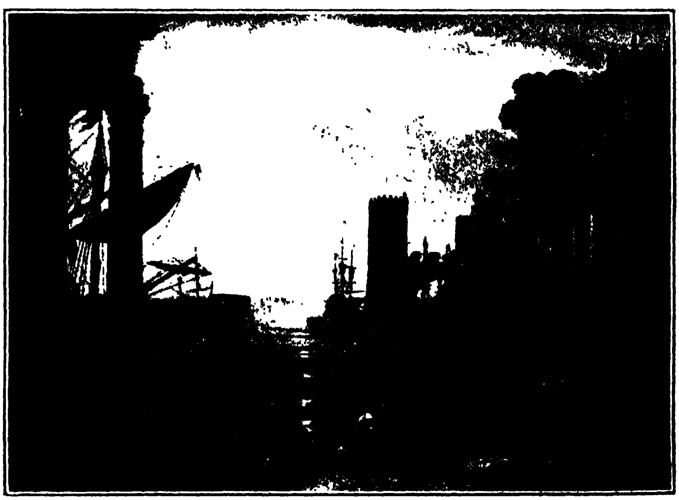
foliage. Like all Dutch landscape painters, Ruysdael and Hobbema excelled in the rendering of cloudy skies, and the latter in the subtle characterisation of varied foliage. Cuyp (A.D. 1606–1672) and Paul Potter (A.D. 1625–1654) remain unequalled to this day as painters of cattle, and must be mentioned here, because both of them, and particularly the former, conceived the animals as part and parcel of the landscape in which they live and which they help to complete.

The Dutch Seascape Painters. Finally, there are the seascape painters, Van de Capelle, Simon de Vlieger, and Van de Velde, all of whom appear more interested in the nautical life of the invariably quiet waters than in the moods of the elements by which the modern painter of the sea is generally fascinated. The real subject of the early Dutch marine painters is thus not the sea, but the varied forms of shipping—fishing fleets, sea-fights, the embarking or landing of an army, sailing craft of every description—in short, the life of the sea. The Frenchman Joseph Vernet (A.D. 1714–1789), though, on the whole, still adhering to the idealistic and classicist tradition, was attracted by the stormy, turbulent aspect of the sea, but there is no terror and passion in his storms. The discovery of the moods of Nature was left to the more nervous modern temperaments.

Watteau. Before we turn to England we must mention Watteau, who, in his perfect balance of figures and landscape, in his rendering of soft atmospheric effects, came very near the modern spirit. The curious point about his art is that he gave a convincing air of reality to scenes which only had existence in his own imagination.

Richard Wilson. Landscape painting in England, in the early part of the eighteenth century, followed two directions, one of which aimed at dry, topographic correctness, and is best represented by Samuel Scott, a talented imitator of Canaletto, the other at Italianised classicism. Of this direction, Richard Wilson (A.D. 1713–1782) is the chief disciple. At his best Wilson is a worthy rival of Claude Lorrain, whose intentions and ideals he had made his own. Thomas Gainsborough is a kind of halfway house between the old style and the new vision which was to be introduced by Constable. His colouring, based on a pleasing scheme of brown, grey, and gold, is still arbitrary and conventional, but his scenes are no longer composed according to established rules. His are in more intimate communion with Nature: he is attracted by the peaceful charm of the English countryside, which needs no classic ruins for its appeal. At the same time his landscapes have still a trace of the artificiality of the period, and lack that fragrance of the soil which breathes from Constable's canvases.

The Norwich School. An important school flourished towards the end of the eighteenth century at Norwich under the leadership of John Crome, better known as "Old Crome" (A.D. 1769–1821), who has, not without good reason, been called the English Ruysdael. He and his

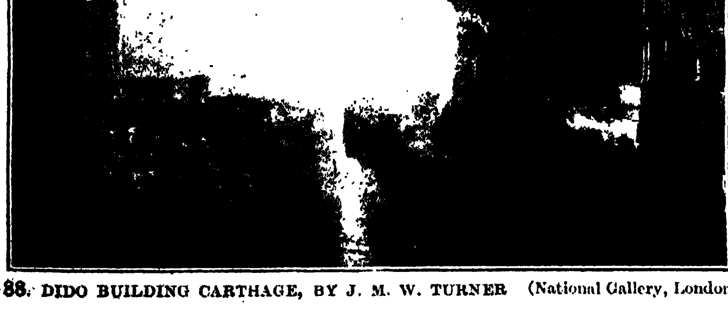


86. EMBARKATION OF THE QUEEN OF SHEBA, BY CLAUDE LORRAIN (National Gallery, London)

87. THE HAYWAIN, BY JOHN CONSTABLE *Mansell*
(National Gallery, London)

followers, among whom Ladbroke, Stark, and Vincent are the most important, show strong kinship with the Dutch landscape school. The same influence can be noticed in the seascapes of John Cotman, another prominent member of the Norwich school. All these painters went to Nature for their subjects, but to the old masters for their colouring. It was the mission of John Constable (A.D. 1776–1837) to discover the juicy green of meadow and wood, the movement of the foliage in the gentle breeze, and the groaning of the heavy bough in the storm. With him the tree ceased to be mere form—he covered the stem with trembling and sparkling foliage; and the sky was no longer a mere grey background, but a dome of atmosphere spanned over fields and gardens and woods. Constable's instinct for balancing the masses of light and shade, and the "full" and "empty" spaces, was such that he could set aside all the hard and fast rules of academic composition. His ardent love of Nature and of the English countryside is expressed in all his work [87]. French artists and critics immediately recognised that he had opened a new page in the book of art, and hailed in him a master worthy of emulation.

The Barbizon School. Perhaps it was Constable's love of Nature, simple, and devoid of all artificiality, that, about 1830, induced a group of French artists to declare war upon the generally prevailing classicism, and to settle down in the little village of Barbizon, in the Forest of Fontainebleau, in order to live in close communion with Nature, and to prove to the world that in landscape the picturesqueness of the subject counts for nothing, that a landscape need be neither classical, nor heroic, nor romantic, as long as the artist can grasp the spirit and the poetry of Nature, and express in paint the emotions aroused in him by its contemplation. "Truth is beauty, and beauty is truth" was the watchword of this group, whose leader was Theodore Rousseau (A.D. 1812–1867), Troyon, Dupré, Jacque, Daubigny, and Diaz being among the other prominent members; while Corot and Millet are so closely affiliated to the Barbizon school that they are generally counted as belonging to it. Corot strikes the most lyrical note of all painters. He is the poet of the twilight, dreamy and musical, and more occupied with the essence and fragrance of Nature than with solid matter [85]. Rousseau is far more impersonal, a searching student of form and structure, while Diaz connects the Barbizon men with the Romanticists. Troyon and Jacque are noted for their magnificent painting of cattle and sheep, and Millet is the painter of the life of the fields, the ceaseless toil of the peasant in his grim struggle with the soil that is to yield him the sustenance of life. [See "The Sower" and "The Gleaners" on page 342.]



88. DIDO BUILDING CARTHAGE, BY J. M. W. TURNER (National Gallery, London)

He is a notable instance of that new beauty (as opposed to the classic beauty) that is to be found in passionate truthfulness to Nature—the beauty of character expressed by synthetic simplification.

Turner and the Sun. Just as the aims of the Barbizon men had been foreshadowed by Constable, so Turner discovered and turned to account the theories that were to be systematised subsequently by the French Impressionists. In his early work he favoured the heroic landscape; but, in his power of rendering sunlight, he is already at this early period immeasurably ahead of Claude Lorrain, his artistic progenitor, as may be gathered from a comparison of Turner's "Dido Building Carthage" [**88**] and Claude's "Embarkation of the Queen of Sheba" [**86**], which are hung side by side at the National Gallery. But if Turner recognised the actual appearance of objects bathed in light and atmosphere, the softening of the outlines, the vibration of the light, he did not apply his knowledge to the service of realism, of landscape "portraiture," as practised later by Claude Monet. He was an exalted idealist, a visionary, who knew how to clothe the glorious inventions of his imagination in real golden sunlight. Characteristic of his attitude is the answer he gave to one who remarked that he had never seen such colours in Nature as appeared in one of his own pictures: "Don't you wish you could see them?" The turning point in the master's art was his visit to Italy, and particularly to Venice. The wonderful atmospheric effects of the lagoon city left an indelible impression on his mind. Henceforth the actual view, the *objects* of the landscape, became quite secondary. The transparency and vibration of the atmosphere, the glory of sunlight, became the real motif of his pictures.

What Impressionism Is. What Turner had achieved, as it were, instinctively, through sheer force of his genius—that is, the analysis of light—was put into what might be called a scientific theory by the French Impressionists, who, in trying to render in paint the full glitter and brilliancy of open-air sunlight, turned to account the results of the scientific research of Helmholtz and Chevreul and the revelations of spectral analysis. The full explanation of the theory of the decomposition of light into its constituents of coloured rays belongs to the sphere of optics. Here it is sufficient to explain that the *technical* reform of Impressionism—for the term embraces other reforms as well—consists of the employment of the primary colours only, which are used in alternate touches and in the right quantities, so that at a certain distance they blend and produce the desired effects. Thus, it is well known that green consists of a mixture of blue and yellow. If, instead of being mixed on the palette, these colours are applied in alternate touches, the effect upon the eye will be a green tone, but a green of far more vibration and greater luminosity than mere green paint. The Impressionist theory has frequently been carried to absurd extremes; but, in the hands of a master like Claude Monet, has yielded results that could not have been achieved by any other method. Of him it may truly be said that light is the one and only subject of his pictures, and nobody has ever come nearer to perfect truth in depicting the glitter and sparkle of sunlight.

89. BATTERSEA BRIDGE, BY WHISTLER
(National Gallery of British Art, London)

Japanese Influences. To-day every country can boast of a large number of landscape painters whose work will live through the ages, but nothing new has been added to the history of the development of landscape art since the advent of Impressionism. Perhaps the next move will be in the direction of a more complete acceptance of the Japanese ideal, which has already exercised a certain amount of influence, notably on the work of Whistler [**89**]. This Japanese ideal is the realisation by art of the universal soul or spirit which underlies the non-permanent, temporary, and therefore unreal forms of matter. The end is achieved by a very broad but exquisitely beautiful and decorative generalisation, which discards all that is not really essential to convey the idea intended by the artist. The attitude of the Japanese artist is pretty nearly reflected by Whistler's reply in a famous law case, when he was asked whether a picture of his produced in Court was a correct representation of Battersea Bridge—"I did not intend it to be a correct portrait of the bridge; as to what the picture represents, that depends upon who looks at it. To some persons it may represent all that was intended. To others it may represent nothing."

Continued

PROCESSES IN RECOVERING METALS

Continued from page 4127

Lead Smelting and Cupellation. Methods of Recovering Silver. Refining Gold. Platinum, Nickel, and other Metals

By A. H. HIORNS

Lead. Lead has been known from remote antiquity, and its use in purifying gold and silver by the process of cupellation is perhaps the oldest metallurgical operation on record. Lead has a bluish-grey colour, and considerable lustre when freshly cut, but this soon diminishes by superficial oxidation. It is very soft, and can easily be cut with a knife and readily marks paper. It is very malleable and ductile, but possesses very low tenacity. It emits a dull sound when struck, but the presence of impurities tends to make it more sonorous. Lead is readily deposited in the form of crystals from a solution of lead acetate by means of zinc, or by electricity. Its specific gravity is 11·37. It begins to fuse at 325° C., but is completely liquid at 335° C. It is a poor conductor of electricity and heat. It is without taste, and emits a certain odour when freshly cut. Lead exhibits in a marked degree the property of flowing when in a viscous state, and advantage is taken of this in the making of lead pipes by forcing the lead through cylinders by means of hydraulic pressure, termed *squirting*. Composition piping contains tin or antimony to harden it.

Lead unites in different proportions with oxygen, of which litharge (PbO) and red lead (Pb_3O_4) are the most important. The sulphide of lead (PbS) is also of great metallurgical importance.

Lead Smelting. The chief ores of lead are *galena* (PbS) and *cerusite* ($PbCO_3$). These ores, especially galena, generally contain silver. The smelting of galena in England and Wales is conducted in reverberatory furnaces. The ore is partially roasted, and then the oxide and sulphide are allowed to react on each other, forming metallic lead. The blast furnace [26] is also used for more complex and refractory ores. In this case it is customary to obtain lead containing silver, regulus often containing copper, and slags.

The lead obtained as above often requires refining. This is done in a reverberatory furnace by exposing the metal to the action of the air, which oxidises the impurities, and these form a dross with some lead oxide, which floats on top of the molten metal. From 30 to 150 tons are refined in one operation. When the lead contains silver it is specially treated for that metal by the *Pattinson* process. This consists of melting the argentiferous lead, allowing it to cool slowly, stirring the while, when the lead separates out in the form of crystals at its freezing point, leaving by far the greater portion of the silver in the liquid portion. Thus, lead containing 3 oz. of silver to the ton may be concentrated up to 800 oz. per ton, which is the practical limit. The process is conducted in a series of nine to fifteen cast-iron pots, each holding eight to fifteen tons. A modification of this method was introduced by Parkes, who added zinc to the argentiferous lead. The zinc separates out on cooling, and carries with it the silver and some lead. These zinc crusts are then submitted to liquation, by which means the lead runs off, carrying with it the silver.

Cupellation. The processes mentioned, therefore, are only concentration processes, and the silver must be separated by cupellation. An English cupellation furnace is a reverberatory furnace with a bed formed of bone ash. When the lead is melted in the oxidising atmosphere of the furnace the base metals are oxidised, while the silver remains unoxidised, and is thus free from all other ingredients, except gold, if that metal be present. Bone ash also has the power of absorbing molten oxides, but not molten silver.

In the German cupellation method the reverberatory furnace is lined with marl, which is a carbonate of lime and magnesia and clay. The air is supplied by means of a pair of inclined twyers fixed in one side of the bed, and the molten oxide of lead flows off through an opening opposite the twyers. This only purifies the silver up to about 95 per cent., so that it is necessary to complete the refining on a bed of bone ash.

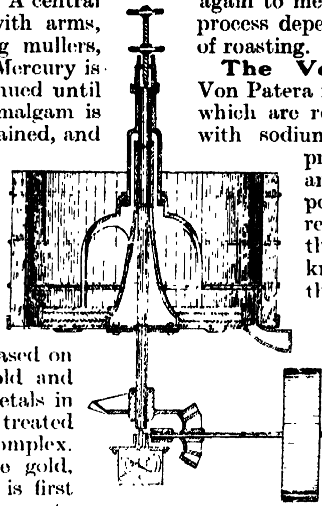
Silver. The properties that make silver so valuable are its pure white colour, its softness, sonorousness, extreme malleability, ductility, tenacity, and toughness. It exceeds all other metals in its conductivity for electricity. It melts at 960° C., and has a specific gravity of 10·53. It does not oxidise in air, although it mechanically absorbs oxygen when melted, and gives it out again on cooling. It readily unites with sulphur, forming a blue crystalline sulphide. With chlorine, bromine, and iodine it unites, forming important compounds. It is soluble in nitric and sulphuric acids.

The ores of silver are of two kinds—the silver ores proper, and silver in ores of base metals. Silver occurs as sulphide, chloride, bromide, and iodide, and in various mixed sulphides as well as in the metallic state.

The methods of extraction are (1) by means of mercury (amalgamation processes); (2) by means of lead (smelting processes); (3) by various wet methods.

Amalgamation. The amalgamation process was formerly carried on in the cold in heaps and pits, as it is at the present time in Mexico. The ore is first converted into chloride by means of a copper salt and common salt, then decomposed by mercury, with which it unites to form an amalgam. The mercury is afterwards driven off by heat,

leaving the silver pure. The amalgamation method is now conducted by means of stamp batteries and amalgamating iron pans. The ore is crushed by stamps, water being admitted. The ore mud is transferred to settling pits, and then carried to the amalgamating pans. The pans are of various types, and consist of an iron box about 4 ft. in diameter and 2 ft. high [30]. A central cone supports a revolving shaft with arms, from which are suspended grinding mullers, which press the ore to a pulp. Mercury is then added, and the rotation continued until the silver is amalgamated. The amalgam is then removed, washed, dried, strained, and the mercury distilled off in retorts. In ores containing much base metal a preliminary roasting in a furnace is necessary, with the addition of common salt to form silver chloride. In this case the ore is dry crushed, and larger pans are used for amalgamating.



30. AMALGAMATING PAN FOR SILVER RECOVERY

Lead Methods of Recovering Silver. Lead methods are based on the reducing action of lead on gold and silver, with the solution of these metals in metallic lead. As complex ores are treated in this way, the products are also complex. The principal metals obtained are gold, silver, copper, and lead. The ore is first roasted in a reverberatory furnace to remove sulphur, arsenic, and other volatile substances, and then smelted in a blast furnace [26]. The charge consists of roasted ores, pyritic ores, various residues, and slags. The products may be lead (containing gold and silver), regulus (containing lead, copper, iron and sulphur) and slag. The last is either used again if it contain sufficient metal, or, if not, it is thrown away. The fume from the furnace is also condensed for the recovery of lead. The lead containing gold and silver is first submitted to the Pattinson process for concentration of silver, and afterwards cupelled for the recovery of gold and silver. The regulus is roasted, and added to another charge in the blast furnace to remove its contained silver and gold. The second regulus may be treated for copper. The gold and silver are separated by the parting process subsequently described.

Wet methods of extracting silver are based on the principle of converting compounds of silver into a soluble form, and then precipitating the silver by means of a base metal or a compound. The three principal methods employed are Augustin's, Ziervogel's, and Von Patera's.

The Augustin Process. The Augustin process is used for argentiferous regulus and residues, which are first roasted in air to remove sulphur, then with common salt, to form chloride. The next stage consists of lixiviating the roasted ore in wooden vats with a strong, hot solution of common salt, which dissolves the silver chloride. The solution is run off and the silver precipitated by means of copper.

The Ziervogel Process. The Ziervogel process consists of roasting sulphur compounds containing silver at a moderate temperature to form silver sulphate, which is soluble in water. The roasted mass is removed, cooled and lixiviated with water, and the silver precipitated by copper. If sufficient sulphur be not present, then pyrites are added. If the temperature be too low, then the sulphate is only partially formed; if too high, the silver sulphate is decomposed again to metallic silver. The success of the process depends on the proper temperature of roasting.

The Von Patera Process. The Von Patera method is used for chloride ores, which are roasted with salt, and lixiviated with sodium thio-sulphate. The silver is precipitated by sodium sulphide, and the silver sulphide decomposed by heat. This method has received extended application by the use of double thio-sulphates, known as the *Russell* process. In the Von Patera process, any lead sulphate that is present dissolves in the thio-sulphate solution, and is precipitated, along with the silver, as sulphide. In the Russell process the lead is precipitated by means of sodium carbonate. Moreover, it was found that by using a double thio-sulphate of sodium and copper, a more energetic decomposing and dissolving action on metallic silver, silver sulphide, and the combinations of silver with arsenic and antimony took place. Hence, if the roasted ore is first treated with sodium thiosulphate to dissolve the silver chloride, and the residues subsequently treated with copper thio-sulphate solution, much more silver is extracted than by the older (Von Patera) method.

Gold. Gold has a yellow colour, its lustre is proverbial, and it exceeds all other metals in malleability and ductility. Its tenacity is moderately high, but is diminished by the presence of lead, tin, antimony, and some other metals, while copper and silver increases it. Its specific gravity is 19·32, and its melting point 1060° C. Its conductivity stands next to that of silver and copper. It is not acted upon by the atmosphere, by hydrochloric, sulphuric, or nitric acids, or by sulphur compounds. It is soluble in chlorine, aqua-regia, and potassium cyanide.

It occurs in nature in the metallic state in quartz and pyrites, and is frequently found in lead, copper, silver, and other ores, in small quantities. It occurs in sands, in nuggets, and alloyed with platinum, silver, mercury, and certain rare metals. In alluvial deposits it is separated by processes which consist of removing lighter matters by running water, while gold, in virtue of its high specific gravity, is deposited.

Gold quartz is very hard and compact, and contains the gold in veins. The ore is first crushed by rock breakers, and then reduced to a fine powder by the stamp battery, the mortar of which is lined with amalgamated copper plates

for taking up the gold. The residual matter is often treated in amalgamating pans. A stamp battery generally consists of five stamps working in one mortar, which is made of an iron casting about five feet long. The feed opening is on one side, and on the other is a fine screen of wire cloth through which the discharge takes place. The drop of the stamp varies from 4 to 18 in., with about 100 blows per minute. In front of the screen are inclined tables covered with amalgamated plates to catch the gold which has not been collected on the plates inside the mortar. The material escaping these plates is concentrated by some kind of shaking machine which separates the lighter from the heavier particles which contain some gold. These concentrates are amalgamated in iron grinding pans. The gold amalgam is retorted to volatise the mercury and retain the gold.

The Chlorine Process. The chlorine process of extracting gold consists of (1) roasting the ore to remove sulphur and base metals; (2) moistening with water and passing a current of chlorine through it in a wooden vat, having a perforated bottom, which acts as a filter, and through which the gold solution percolates; (3) running off the solution and precipitating the gold by iron sulphate or other suitable reagent. Ores and residues are usually concentrated before being submitted to the chlorination process. Compressed chlorine is also used and is very effective, but more expensive. The operation is conducted in revolving barrels lined with lead.

The cyanide process of extracting gold was introduced by McArthur and Forrest, in 1887. The ore is first crushed in rock breakers, then in rolls or stamp batteries, then placed in vats to which a 1 per cent. solution of potassium cyanide is added, which dissolves the free gold. The solution is then removed, and the gold precipitated by means of zinc.

Gold is extracted by smelting processes from rich copper regulus. The method is the same as explained for extracting copper by the Welsh method. The regulus is partially roasted, and then the oxide and sulphide react on each other, reducing the copper and gold, forming an alloy. The copper is deposited by the electrolytic method, when the gold is left, and is afterwards melted with lead and separated by cupellation.

Refining and Parting of Gold. Impure gold is melted in crucibles, and the impurities, if small, may be fluxed off with carbonate of soda and nitre. If much impurity be present, the gold is first refined by adding nitre and borax, a little at a time, and skimming off the slag at the completion. If lead be present, sal-ammoniac and nitre are used. If antimony and arsenic be present, adding nitre and stirring with an iron rod will remove them. Gold may be also refined by passing through the molten metal a current of chlorine, which attacks the base metals and silver, forming chlorides. When much impurity is present, the operation known as parting is adopted. This is usually done, on the large scale, with sulphuric acid, and in assaying, with nitric acid. It is first necessary to alloy the impure gold with about three times its own weight of silver, granulate and boil in white cast-iron pots with sulphuric acid, which dissolves all metals except gold. In the nitric acid method of parting, glass vessels are used.

Platinum. Platinum is a white metal, highly malleable and ductile, soft, and can be easily welded, very tenacious, and has nearly the highest specific gravity of all kinds of matter. Its specific gravity is 21·5. It resists the action of the atmosphere and most acids, and has an extremely high melting point. It occurs in nature, like gold, in the metallic state, in grains, nuggets, and various alloys. It is extracted from its ores by both dry and wet methods.

In the wet method, gold and silver are separated by amalgamation, the residue is digested with boiling nitric acid, then with aqua-regia to form platinum chloride. The solution is evaporated, redissolved in water, and mixed with alcohol and ammonium chloride, when the double chloride of platinum and ammonium is precipitated. This is reduced to metallic platinum in a plumbago crucible.

In the dry method the ore is smelted in a reverberatory furnace with lead ores, thus forming an alloy with lead and platinum, which is afterwards cupelled. The product is then melted on the lime hearth of an oxyhydrogen furnace.

Nickel. Nickel is a brilliant white metal, malleable, ductile, and weldable. Its melting point is about 1,500° C., therefore below that of iron. It is a magnetic metal and one of the hardest, hence its value as a coating for softer metals. Its specific gravity is 8·8. It readily unites with oxygen when heated, but is not readily oxidisable at ordinary temperatures, and resists the action of sea-water better than most metals. It is soluble in hydrochloric, nitric, and sulphuric acids. Nickel, like iron, readily unites with carbon and silicon when fused with them. When carbonic oxide is passed over nickel at 80° C., or less, a volatile nickel carbonyl is formed which may be decomposed at a higher temperature yielding the nickel. The ores of nickel are chiefly sulphides and silicates.

Nickel Extraction. The methods of extraction are several, and include (1) concentration by roasting to form regulus or speise; (2) the conversion of the above into oxide by wet or dry methods; (3) the reduction of nickel oxide by carbon. As cobalt is frequently present, it may be practically separated by the superior affinity of nickel for sulphur or arsenic and the greater tendency for cobalt to pass into a silicate slag.

By the wet method the arsenide and sulphide ores are first roasted, and the other elements are separated from nickel by converting the iron into a basic arseniate, the copper into a sulphide, and the cobalt is precipitated with bleaching powder. After filtering, the nickel is precipitated as oxide with lime. This oxide is then reduced with carbon.

The silicate ores of nickel are made into a paste with calcium sulphate or alkali waste, pressed into bricks and smelted in a small blast furnace. The product is a matte (sulphide). This

is roasted, fused twice with sand to remove iron and to concentrate the nickel. The nickel sulphide is then roasted to oxide, and the oxide is made into a paste with carbonaceous materials and reduced to the metallic state in iron pots in a reverberatory furnace.

In Canada, pyritic ores are found containing about equal amounts of nickel and copper. The ore is first roasted in heaps and then smelted with coke in a water-jacketed blast furnace to produce a rich copper-nickel matte. This is re-melted and blown in a Bessemer converter to remove sulphur and iron, the latter completely and the former only partially, leaving a rich matte of copper and nickel. This is then roasted and reduced in the usual way to form a copper-nickel alloy.

Mond's Carbonyl Process. Dr. Mond found that when carbonic oxide is passed over recently-reduced nickel at a temperature below 150° C., a compound ($Ni[CO]_4$) termed *nickel carbonyl* is obtained. A method is thus available for the separation of nickel from its associated metals. An oxidised ore or roasted pyrites is heated to 400° C. in water gas, which reduces the nickel to the metallic state. The nickel is then allowed to fall over shelves in a cylinder, kept at 80° C. or less, through which a current of carbonic oxide is ascending, thus forming nickel carbonyl. This is conveyed to a series of tubes and heated to 180° C., whereby the carbonyl is decomposed and nearly pure nickel is deposited on the walls of the tube.

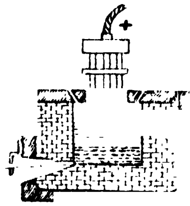
Nickel, when reduced from its oxide, is always wanting in malleability and ductility. It is rendered malleable by adding to it when melted a small portion of magnesium or manganese. Nickel cast into slabs is largely used as anodes in nickel-plating, but wrought plates are better, being less soluble and more uniform in structure.

Cobalt. Cobalt is a metal of a steel-grey colour, with a reddish cast, and very similar to nickel in many of its properties, but of greater rarity and higher cost. It is used in alloys and for electroplating.

Aluminium. Aluminium is a white, somewhat soft metal, of considerable lustre, highly malleable and ductile, a good conductor of heat and electricity, with a high specific heat and low specific gravity. Its elasticity and tenacity are a little higher than silver. It is highly sonorous. The atmosphere has little action upon it, dilute nitric and sulphuric acids do not affect it, but hydrochloric acid dissolves it readily. It is also soluble in solutions of soda and potash. It is chiefly used for purposes where lightness is required.

It occurs in most silicates, and those in which alumina predominates are used for its extraction. As oxide it occurs in corundum, and as fluoride in cryolite.

Alumina was first extracted from its ores by forming the double chloride of sodium and aluminium and displacing the aluminium by sodium. It is now extracted by electrolysis or by electric smelting, through the agency of electricity in both cases. The Hall and Heroult processes are among the most successful. They are identical in principle and both patented in 1886, one in America and the other in France. The Heroult cell [31] consists of a carbon-lined box, itself forming the cathode while the anode is formed of a bundle of carbon rods. The bath consists of molten cryolite holding alumina in solution. The temperature of the bath is about 800° C., and an electric pressure of 3 to 5 volts is sufficient.



31. HEROULT CELL FOR ALUMINIUM

The current density employed is about 700 amperes per square foot of cathode surface. The yield is 1 lb. of aluminium per 12 electrical horse-power hours. The alumina used is prepared from bauxite or an impure oxide of iron and alumina by a chemical process. The Cowles process for the extraction of aluminium had a considerable commercial success, but is now, we understand, not carried on. It employed a granular body of high resistance which, being interposed in the current, produced great heat. The alumina is mixed with this resistance material, which is carbon, and by its reducing action at the high temperature employed reduced the alumina to aluminium. It is essential that the air be excluded. This method is now confined to the preparation of aluminium alloys.

Zinc. The metal zinc has a bluish-white colour, a highly crystalline fracture, and a melting point of 420° C. It soon tarnishes in air, and is readily volatile at a little above its melting-point. Its specific gravity is 7·15. It contracts but little on cooling from the liquid state, and is therefore an excellent metal for casting. In the cast state it is known as spelter, and in the rolled state as zinc. It is malleable only between 100° and 200° C. Common zinc is somewhat soluble in boiling water, and readily so in dilute acids. Although zinc readily oxidises it does not combine with sulphur by direct union. The chief impurities in commercial zinc are lead, arsenic, iron and cadmium. The chief ores of zinc are *zinc-blende* (ZnS) and *calamine* ($ZnCO_3$).

Zinc, being a volatile metal, is extracted by a method of distillation. The ore is first calcined to form oxides, then placed in retorts with anthracite (carbon) and strongly heated. The oxide of zinc is reduced and the metal condensed in fireclay retorts [29]. For rolling it is necessary that zinc should be refined, which is done on the hearth of a reverberatory furnace, made to slope down to a cavity at one end, into which the zinc flows. The bulk of the lead sinks to the bottom, leaving not more than 1·1 per cent. in the zinc. Iron is not removed by this process. Zinc is used for gutters, cisterns, baths, chimney tops, roofing, etc. It is largely used for coating sheet iron, termed *galvanising*.

Tin. Tin is found in nature as oxide, and Cornwall has been from a remote period noted for its tin mines. The ore first undergoes a mechanical preparation to concentrate it. After this it is calcined to remove volatile matter, and then smelted in a reverberatory furnace with anthracite coal to reduce the metal. The products are tin and slag. The tin contains various impurities, and is refined by liquation and poling. By liquation the tin flows out, leaving much of the foreign matter behind. The poling causes evolution of gas, which agitates the metal and brings the impurities to the surface, forming a dross. The varieties of commercial tin are *common* or ingot tin, and *refined* or grain tin. Tin plate is sheet iron coated with a layer of tin to prevent oxidation of the iron. The best iron plates are produced from ore smelted with charcoal, and termed *charcoal plates*. Copper is also tinned in some cases, as for cooking utensils, to prevent the food being contaminated with copper salts. Phosphor-tin is tin alloyed with 4 to 6 per cent. of phosphorus, and used for making phosphor-bronze.

Tin is a white metal of low tenacity but great malleability. When a bar of tin is bent it produces a crackling sound known as the *cry of tin*. It is very prone to crystallise, and when the surface is washed with aqua regia the crystals are clearly seen; this is termed *moiree metallique*. The specific gravity of tin is 7·3, and its melting point 232° C. When tin is just melted and allowed to cool, the surface remains bright if the metal be pure, but the presence of lead, iron, etc., tends to impart a frosted appearance. The impurities in common tin are lead, iron, arsenic, copper, bismuth, tungsten, and sometimes manganese and zinc. Tin is a poor conductor of electricity. It is capable of assuming an allotropic form, crumbling to powder when exposed to a very low temperature.

Antimony. The chief ore of antimony is stibnite (Sb_2S_3). This sulphide may be largely separated from the rock in which it occurs by liquation. This is done on the concave hearth of a reverberatory furnace, which is lined with charcoal to prevent oxidation. Antimony was formerly called *regulus of antimony*, and in this country is extracted by reduction in crucibles by metallic iron. The metal is purified by fusion with nitre, or by melting and stirring with an iron rod.

Antimony is a bluish-white metal, highly crystalline and brittle, with a specific gravity of 6·7. The surface of the cast metal shows characteristic fern-like markings. It expands on solidifying, and imparts this property to many of its alloys. It melts at 632° C. It does not oxidise in air at ordinary temperatures, but, when heated, unites with oxygen to form the white oxide, Sb_2O_3.

Antimony is too brittle to be used alone for most purposes, but it is of great service as a constituent of certain alloys. It is used to harden lead and tin. It is very valuable in type metal, imparting the property of expansion so necessary for obtaining a sharp and well-defined impression of the letters when printing.

Arsenic. Arsenic is a brittle metal of a steel-grey colour and metallic lustre. Its specific gravity is 5·7. It is a poor conductor of heat and electricity, and in the pure state is without taste or odour. It is very volatile, and burns in air with the formation of the white oxide, As_2O_3. It is a constituent of shot metal and other alloys. It is a valuable bronzing agent. The ores are sulphides, but it occurs chiefly in ores of other metals, such as those of nickel and cobalt. It is extracted from its ores in retorts, from which, on being heated, the arsenic sublimes and is collected.

Bismuth. Bismuth is a comparatively rare metal, associated chiefly with ores of nickel, copper, and silver, from which the crude metal is separated by liquation, or smelted by roasting and reduction in crucibles with iron and carbon. The raw metal is refined with nitre. Bismuth is a reddish-white metal, highly crystalline and brittle. Its low melting point and its property of expanding during solidification make it useful as a constituent of certain alloys, such as fine solder and type metal. It melts at 268° C., its specific gravity is 9·8 in the solid and 10 in the liquid state. It burns in air with a bluish-white flame, forming bismuth oxide (Bi_2O_3). Bismuth, like lead, may be used as a solvent metal in the process of cupellation. It is used in the construction of thermo-piles, in fusible alloys, and in some kinds of type metal and stereo metal.

Mercury. Mercury, or quicksilver, occurs in nature in the metallic state and in *cinnabar* (HgS). The metal is extracted from its ores by a distillation method. The ore is heated in a special furnace, and the vapours of mercury condensed in condensing chambers. The crude metal may contain lead, bismuth, zinc, cadmium, and other impurities. It is purified by covering the metal with dilute nitric acid, and allowing it to stand some time; the acid gradually dissolves out the base metals, together with some mercury. It is finally redistilled, and is thus made practically pure.

Mercury is a silver-white metal, liquid at ordinary temperatures, and boils at 360° C. Its specific gravity is 13·6. It is not affected by air or oxygen at ordinary temperatures, but if any discoloration occurs on shaking it in a bottle it indicates that impurities are present. It is used somewhat in gilding, but chiefly in the extraction of gold and silver, and in the construction of thermometers, barometers, etc. In dentistry, mercury is a constituent of dentists' preparations and alloys.

Magnesium. Magnesium is a metal very similar to aluminium, but whiter and lighter, its specific gravity being only 1·74. It melts at 750° C., and boils at about 1,100° C. It is rather more oxidisable than zinc. It is best worked at a temperature of 450° C. Magnesium wire is made by forcing the heated metal through holes in a steel plate, and magnesium ribbon is made by passing the metal between heated rolls. It is used in the refining of some metals, owing to its great affinity for oxygen and other non-metals. It is a constituent of some alloys, such as magnalium, which is composed of 100 parts aluminium and 10 to 30 parts of magnesium.

Continued

Continued from page 4184

MANDOLINE. BANJO. AUTOHARP. DULCIMER

Construction of Instruments. Position of Player. The Strings. Tuning. Fingering and Special Effects. Exercises

By ALGERNON ROSE

THE MANDOLINE

The mandoline derives its name from the word "mandorla," an almond, the shape of which nut suggested the outline of the body of the instrument. There are two kinds of mandolines—those with four pairs of strings, known as the "Neapolitan," and those with five pairs, called the "Milanese." As the five double-strung instrument is rarely met with, we will devote our attention to the Neapolitan variety.

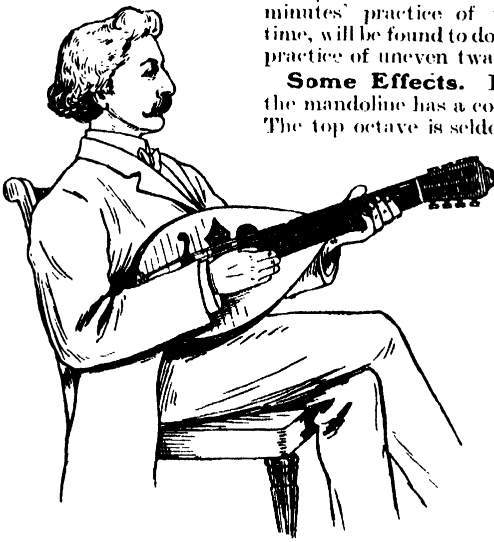
The Strings. The top string is E, the second A, the third D (called the Bourdon), and the fourth G, the lowest pair being gut strings overspun with silver or copper wire. Therefore the tuning of each pair resembles the tuning of the single strings in the violin namely, in fifths. The D strings are of steel, also covered; but the A and E strings are of plain steel.

The small metallic bars which cross the fingerboard beneath the strings (there are usually 27 of them) are known as *frets*. Between each fret the space represents one note on the pianoforte, or a semitone in music. In manipulating the fingerboard, the player must be careful with his left hand to place down each finger as firmly as possible, or the metal strings will chatter against the frets and cause an unpleasant buzzing. Play with the finger-tips; they will get sore at first, and contact with the wires will produce corns, but the student will not long be inconvenienced by this.

Position. The position of the player is like that of the guitarist. Sit on a chair; cross the right leg over the left, or put the right foot on a high stool. Hold the body of the mandoline firmly between the knee and the chest, so that the player's right forearm may move freely. The head of the instrument (containing the tuning pegs) should project a handspan beyond the left shoulder. Be careful to keep the right hand and wrist firm, so as to clear the strings and bridge. Keep both elbows down. [1]

The strings are set into vibration by the use of a *plectrum*. One of real tortoiseshell will last for months, but the genuine article is not easy to obtain nowadays, celluloid, which is less durable, being sold in its place. With the plectrum the instrument is played either *tremolo* or *pizzicato*. The former method sustains the tone and the latter breaks it. The tip of the plectrum should be flexible, and the wide end quite firm. Hold it at right angles to the strings with its flat side in a line with them, or place it between any pair of strings. While grasping the plectrum firmly, keep the rest of the hand limp.

To tremolo properly, it is unnecessary to use force. Strike the strings gently, first down and then up. Make the motions of the same strength, so that both wires are struck equally. Do not attempt to tremolo fast before being able to do so evenly and slowly. In other words, before trying to run, learn to walk. We have heard of a beginner tying a watch to his ear and regulating the speed of his tremolo by its ticking. Fifteen minutes' practice of this kind, keeping strict time, will be found to do more good than an hour's practice of uneven twanging.



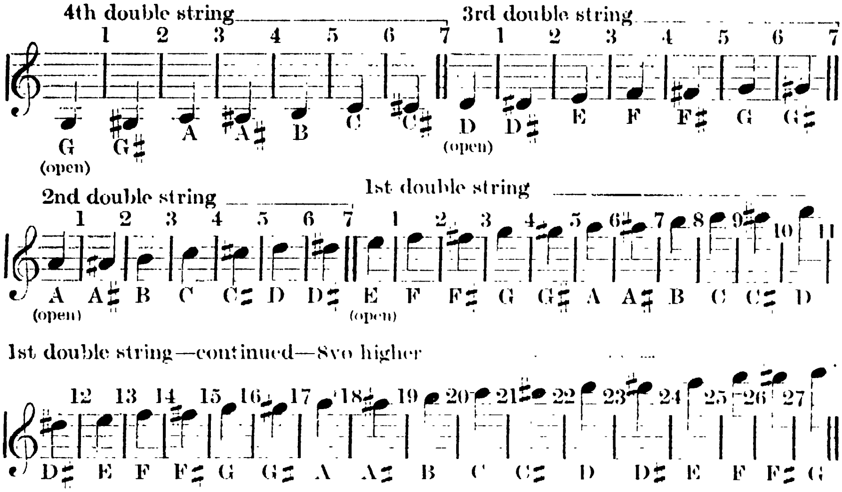
1. HOW TO HOLD THE MANDOLINE

Some Effects. From bottom G upwards, the mandoline has a compass of four octaves [2]. The top octave is seldom used.

It should perhaps be here mentioned that a knowledge of musical theory is presupposed [see page 37]. When the student has played with the plectrum the first octave of the different major scales indicated in the course for the violin [page 2121], he should repeat them with the left hand alone. Hammer out each note on the frets with the fingers. Try to produce as much tone as possible without touching the strings with the plectrum. This is an excellent exercise for strengthening the fingers of the left hand and making their movements independent of each other. The effect produced by a good mandoline player who by practice has made his little finger apparently as strong as his first is not unlike that of the soft percussion stop in a Mustel harmonium.

Another mandoline effect which must be studied is the *slur*, known also as the *legatura*. This is indicated in notation by a curved line

The bars represent the frets. Press the strings between *on* the spaces between the frets



2. COMPASS OF THE MANDOLINE

linking together two or more notes. To insure the tremolo continuing without the slightest break, the player, at the beginning of a slur, strikes the strings once only. By gliding the fingers of the left hand firmly up or down the fingerboard, the tone is then carried from one note to another without further stimulus.

Another speciality of the mandoline is the *echo* effect. As the word implies, it is an iteration, softly, of a chord or arpeggio already played. The way to get this is simple. The plectrum, being held by the thumb and first finger, leaves disengaged the second, third, and fourth fingers. After striking with the plectrum loudly, draw the disengaged fingers across the four strings in an upward direction.

The production of harmonics is a distinct charm of the mandoline. These dulcet sounds are elicited by touching the string lightly immediately above the fourth, fifth, seventh, or twelfth frets. At the same time strike with the plectrum. Then take both the hands off so as to set the string free to continue the vibration.

Another distinctive feature in mandoline playing is the *strappato*. In English this means to wrench or pluck off. Strike the intended chord downwards, arpeggio fashion, then bring the plectrum quickly upwards across all the strings. As a close to a brilliant march or other similar music, it gives a good finish, and should, therefore, not be overlooked by the ambitious player.

A Fault to Check. One word in conclusion. A common fault in practising a solo instrument is the tendency to disregard precision in time, by hurrying over an easy passage and slowing down when any difficulty occurs. The best remedy for this is ensemble playing. A beautiful quartet, for which good music has been written, can be formed by associating together a first and second mandoline, a mandola, and a guitar, the latter playing the bass part [Ex. 1].

The best known examples of employment of the mandoline in the orchestra occur in Mozart's "Don Giovanni," Handel's "Alexander Balus," and Paisiello's "Barber of Seville."

Ex. 1

TARANTELLA (Italian Dance)

Practise slowly at first. Gradually work up the time till it is *Presto*

THE BANJO

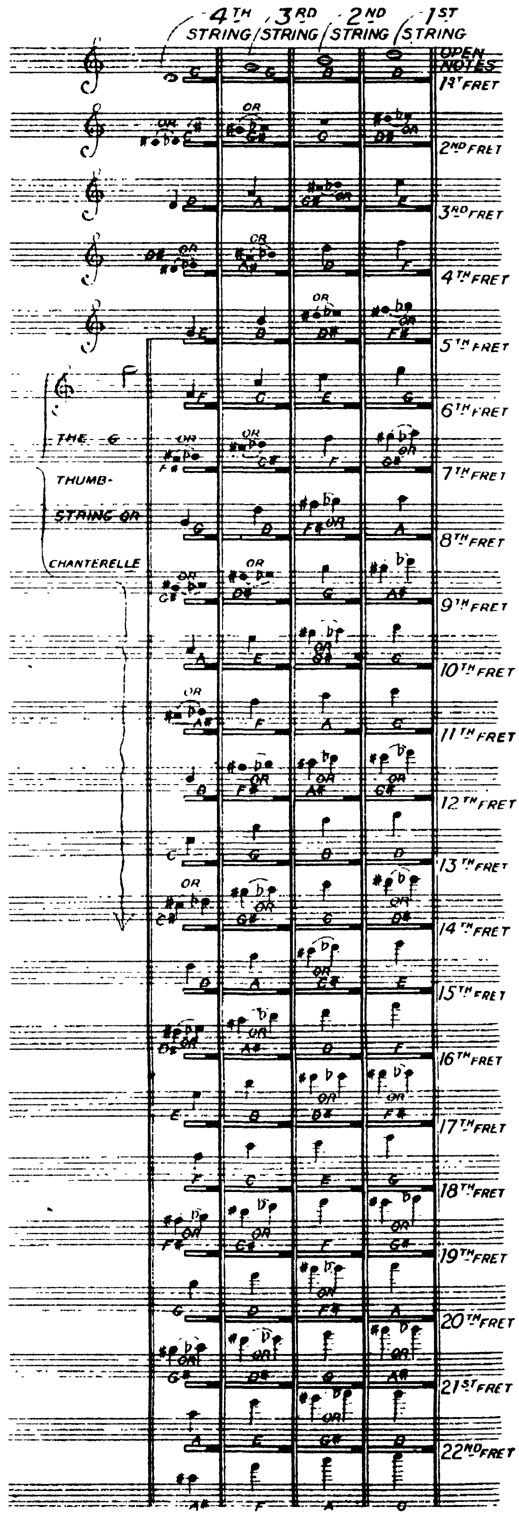
The banjo is in no way descended from the European lute or guitar family. It is of African origin, and through the negro slaves of the Southern States of North America the banjo gradually became popular with our white transatlantic cousins. From America it came to Great Britain and the European continent.

The banjo is characterised by its circular body, or hoop. The head of the banjo is open underneath like a tambourine, or like the half gourd used in many negro instruments as a resonator. Without a fairly deep rim, or hoop, the banjo would lose much of its tone. The rim, therefore, acts as its sounding-board. From the hoop extends a long neck, sometimes called the "handle." This is usually of walnut, the upper surface being overlaid with an ebony fingerboard, across which, at lessening intervals, are narrow ridges of metal called "frets."

Construction. A peculiar feature in the construction of the banjo is the way in which its shortest string is placed. This is known as the "chanterelle," or, literally, its "singing" string. Instead of being in its natural order, as the top string is in European instruments, it is put next the lowest and longest string on the fingerboard. This is suggestive. The thumb of the negro, constantly employed for climbing, is said to be rather longer than that of the white man. At all events, this is the thumb-string, and expert banjoists are as dependent on the thumb for their success as was any gladiator—in another sense—in the arenas of ancient Rome. The thumb-string on the banjo being shorter than the other four, its tuning peg is situated two-thirds of the way up the neck instead of at the head. Advanced players sometimes favour six, seven, and even nine stringed banjos. But the beginner will learn the ordinary instrument, which has five strings. Their pitch is an octave lower than the notes indicated in music printed for them.

Tuning. Tune the fourth string to the C on the piano, second space bass clef. That is the actual sound, although in the music it is represented as C, first ledger line below treble staff. Having done this, tune the third string a fifth above the fourth, to G in the fourth space bass clef. Next adjust the second string a third above G—namely, B. Now tune the third string a third above B, to D. Do not tune each by the piano. Only use it to test the strings when they are tuned. As soon as the C string has been adjusted to the pitch, its seventh will give the G for the third string. Likewise, the fourth fret of the G string, when tuned, will give the B for the second string, and the third fret of the B string will give the D for the first. Now stop the fifth fret of the first string and tune the thumb-string in unison with it. If this is done properly, it will be an octave higher than the open G of the third string.

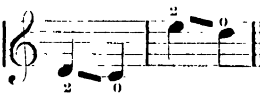
The banjo is best played sitting. Cross the right leg over the left. Rest the fore part of the hoop on the leg. The near side of it should be in contact with the player's chest, and thus be



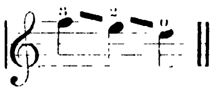
held firmly. The handle, which now inclines over the left shoulder, is manipulated by the fingers of the left hand. Rest the little finger of the right hand on the vellum sounding-board, in a line with the bridge.

There are two general methods of banjo playing. The first, and more usual, is by picking, or plucking, with the tips of the fingers of the right hand. The second method, which increases the sound for concert playing, is by the thimble. This is worn over the nail of the first right finger. With it the strings, instead of being pulled, are struck downwards.

Exercises. Begin with the exercise on the open strings. Grasp the handle with the thumb and second joint of the first finger. Keep the left fingers clear of the strings. Remember that the right thumb is used for the three strings on the left. The first finger is employed for the second string, the second right finger for the



1. SINGLE SNAP



2. DOUBLE SNAP

first string. But the third finger is only used occasionally, as in chords or arpeggio passages.

Now study carefully the proper fingering for the left hand. It may seem complicated at first, but after a certain amount of practice it should become automatically correct. All the sounds which the five strings produce on pressure of the twenty-two frets are noted in the accompanying table. The "chanterelle," or thumb-string, being higher in pitch, has intervals shorter than those of its neighbour. [See last page.]

Reference to this diagram should enable the student to finger out for himself any music he wishes to study.

The easiest scale to play on the banjo is G major, with one sharp, F. This is the natural key of the instrument. Therefore learn that scale first. The fingering is shown in 3.

Observe that, when the first finger of the left hand covers the first fret, the hand is said to be in the *first position*. Now let the first finger fall on the second fret. The hand is now in the *second position*. According to the way the hand progresses along the fingerboard, so is it in the *third*, *fourth*, or *fifth positions*.

The Strings. Bear in mind that the strings cannot be pressed too strongly by the fingers of the left hand if a good tone is to be acquired. There is a marked difference between the quality of an open string and of the same string when stopped by the finger of an ordinary amateur. The reason is because the pressure, or stress, on the string at the point where it goes over the top-nut, and is pulled back by the reverted head of the instrument, is enormous. Try to make each finger a top-nut.

The popular "breakdown," or step-dance, known as "Old Virginny" may now be practised [Ex. 1].

Next proceed to the scale of C major. Later on, study all the sharp and then all the flat scales. With perseverance, difficulties will be overcome.

Meanwhile, the intelligent student will study that feature in banjo playing known as the *snap*. This is indicated in notation by a straight line drawn from one note to another [1].

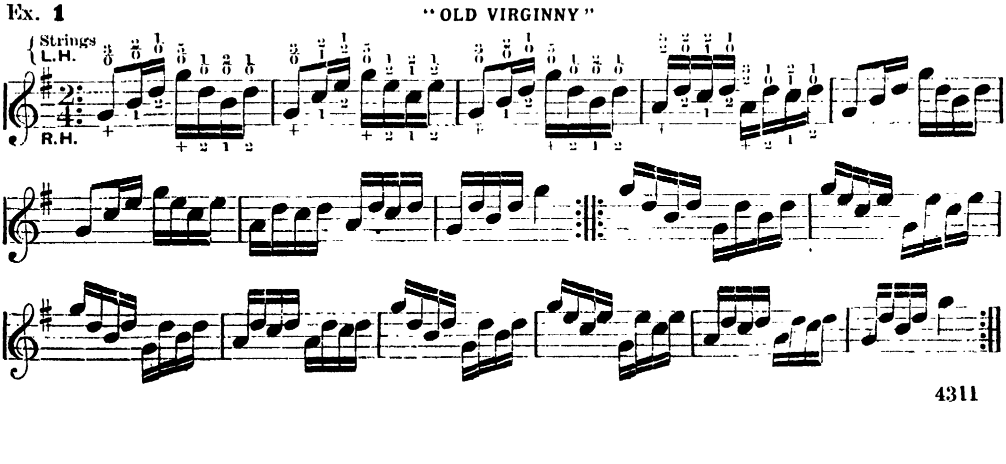
Produce the first sound by plucking the string with the right hand. Then, with the left finger,

3. FINGERING OF G MAJOR

snap—or pizzicato—the note which follows. Having succeeded in doing the *single snap* neatly, try playing the *double snap*. As before, pluck the first note with the right hand. Then, with the left, snap the *two* following notes [2].

Owing to the presence of frets, it is easy on the banjo to transpose the sounds of the strings by placing the first left finger across them. To do this properly, the thumb must be at the back of the neck, away from the chanterelle, so as to act as a lever.

Ex. 1 "OLD VIRGINNY"



Barré. This method of transposition is termed *barré*. According to the position barré, so it is indicated in the music as 1 P.B., 2 P.B., 3 P.B., etc. The first finger must be planted firmly, seeing that it cuts off a vibrating portion of the neck and forms a fresh top-nut, or *capotasto*. Beyond this new top-nut, the second, third, and fourth fingers stop the notes as required.

When a slur in the printed music ties one note to another by a curved line, the way of playing is to slide the finger which stops the first note firmly on to the second while the string is vibrating. What is technically known as the *slide* is the longer slur. Of this there are several kinds. In playing barré, the fingers forming the notes beyond the bar should, like the first, press firmly. If, on the contrary, they touch the strings above the frets very lightly, the effect is that of a silvery note at a higher pitch. This is known as a *harmonic*. It has a bell-like or fluty character. The principal harmonic notes on the banjo are obtained by touching softly the fifth, seventh, and twelfth frets, or the seventeenth fret on the thumb-string. So as to be easily read, harmonics are usually written an octave lower than they sound. The harmonic at the nineteenth fret of the thumb-string is analogous to the seventh on the third string.

The Vibrato. We have so far dealt with various ways of stopping the notes; but, besides pressing them down firmly, the student who desires to be a good banjo player will practise diligently until he acquires the ability to cause each finger of his left hand to make the string throb or quiver sympathetically. This delightful effect is known as the *vibrato*. Not only is the pulsating tone pleasant, but its production seems to reinforce and intensify the sound of the instrument. Regard the tip of the finger as a fulcrum. Press the first joint gently forward and backward. Do not jerk the string. The necessary rapidity of motion requires practice, especially as regards the weaker fingers. The only way is to repeat the exercise patiently day after day until the knack is acquired. It will probably come when least expected. When once learnt, it is not forgotten. The time occupied in obtaining it is well spent, because it is not easy to exaggerate a good vibrato on a stringed instrument, whereas the same effect applied to the voice too often becomes a wearisome mannerism, which militates against the success of the vocalist.

Varieties of style of manipulation in banjo playing done with the right hand are known as the *tremolo, fanning, thimble playing*, and the *rasp*. An even tremolo is nearly as difficult to learn at first as is the vibrato for the left hand. It is produced by the tip of the first finger very quickly beating the strings to and fro. At the same time, the lower notes, furnishing either accompaniment or melody, are played by the thumb. Fanning, although somewhat similar, is more deliberate than the tremolo.

Thimble playing is employed when a powerful tone is required. The first finger strikes the strings with the thimble instead of twanging them, the thumb meanwhile plucking alternate notes in the usual fashion. A further development of this branch of study is known as *thimble rolling*. Like everything artistic, it usually requires considerable practice to obtain a good effect. Although the harpist keeps his nails very short, the banjoist, like the Chinese mandarin, must cultivate his for playing the rasp. This is produced by passing the finger-nails of the right hand lightly across the strings, either with the back of the hand up or the palm up and the nails reversed.

Sufficient has been said to show that, although the rudiments of banjo playing are easy to acquire, the instrument is not easy to master thoroughly, and amongst its exponents are not a few players of extraordinary skill.

But the student will find that its difficulties will vanish with persistent, well-ordered practice.

THE AUTOHARP

This instrument is in shape like the zither rather than the harp. The distinguishing feature in its construction is that the strings are crossed at right angles by bars parallel to each other. By means of spiral springs, each bar is kept clear of the wires below except when pressed down. An arrangement of pieces of felt then damps the vibration of certain strings, allowing the others to sound freely.

Place the autoharp on a flat table, taking care that the spikes do not scratch the surface, with the straight side of the instrument inclining towards the player at an angle so that the outlines of the fingerboard and bass side represent roughly the letter V. Every string is numbered underneath on the sounding-board. Corresponding numbers are printed over each note in music arranged for this instrument. No previous knowledge of notation is therefore necessary.

The Strings. Of the twenty-four strings to be found in the usual type of autoharp, those nearest the player are of covered wire. These strings represent the pedal notes, or roots, of chords formed on pressing the bars and sweeping the strings. With the left hand press down the bar nearest the tuning pins. Set the strings in motion by guiding the thumb of the right hand along them. The notes which sound are C, E, G, wherever they occur throughout the compass, the other notes being silenced by pads of felt underneath the bars [1*a*].

Now depress the next rod, marked B. Sound the strings. The chord heard includes every D, F♯, A, and C in the scale [1*b*].

The third bar, marked C, leaves open every G, B, and D in the compass [1*c*].

All strings which sound E, G, B vibrate when the fourth bar, marked D, is put down [1*d*].

The fifth bar, marked E, sounds every A, C, E [1*e*].

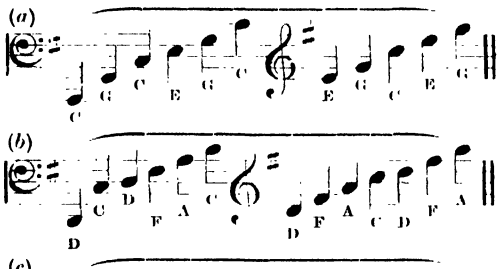
Lastly, when the sixth bar, marked E, is pressed, it allows every B, D, and F♯ to vibrate [1*f*].

All melodies for the simple autoharp are written in the key of G, with one sharp, F.

The compass usually consists of twenty-four or twenty-five strings, being the diatonic scale of G, to which are added the pedal notes of C and D, and harmonic sounds can be obtained by touching the G string (4) lightly above the frets (beyond the bars)

Although the autoharp may be played by those who know nothing whatever of musical notation, in the hands of a musician who understands the principles on which its mechanism is arranged it is something more than a mere toy. He can elicit some beautiful effects from it, inasmuch as the third bar gives the tonic chord of G major, the second the dominant, the first the subdominant, the fourth the relative minor chord of G, the fifth the relative minor chord of the sub-dominant, and the sixth bar the relative minor chord of the dominant.

To show what can be done in the way of autoharp music, we may mention that the so-called



1. AUTOHARP EFFECTS

"Erato" autoharp has a compass of three full octaves from C to C, containing all the semitones, and its elaborate mechanism enables thirty-six different chords to be played—namely, the twelve major, twelve minor, and twelve chords of the seventh.

Use of the Ring. For sweeping the strings, an ordinary zither or banjo thumb-clip of celluloid, called a *ring*, is used. If the ring is too small, it will make the player's thumb sore; if too large, it will spoil the accuracy and firmness of tone. Therefore, see that it fits. By holding up the thumb and sweeping the strings with the tips of the other fingers, a delightful pianissimo effect is obtained. To silence the sounds, put the flat of the left hand on the strings.

Tuning. But the charm of the instrument will be entirely lacking if the strings are not in good tune. Be careful to get a tuning hammer, or key, which is of hard metal, and fits the pins properly. If it slips on the pins, the latter will be racked and gradually loosened, and the instrument soon spoilt. An easy guide to the tuning is to follow the notes indicated on a piano or harmonium. When the player gets accustomed to the sounds required, the help of a keyboard instrument may be dispensed with, and the tuning done from a G pitch-pipe or tuning-fork.

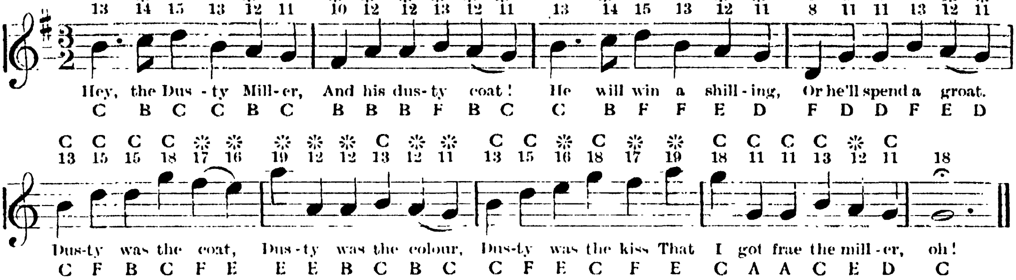
On the autoharp with six bars, the G string is usually the ninth from the left. In some instances it bears the number 4, pedal notes being marked with Roman numerals to distinguish them from the diatonic intervals above. But the letter of each note is printed on the instrument itself, so that one cannot make a mistake.

If 4 is the number of pitch G, the strings 6, 8, and 11 will give the notes B, D, and the octave G, found under the third bar, marked C. Press down this bar and keep it down with a paper-weight while tuning these strings, so as to shut off the sounds of the others. Put the tuning hammer on the pin of B (No. 13), an octave above B (6), which tune next; then tune pedal B (IV.) two octaves below. Deal in the same way with the three D's, 8, 15, 1. Tune 18 and III. with pitch G (11) and its octave (4). Now release bar C, and tune the intermediate notes with their octaves. Test them with the bars of C major ("A" bar), and the dominant of G ("B" bar). As the same strings are employed in forming the relative minor chords, it follows that, when the strings sounded on pressing the first three bars are tuned correctly, they will accord also when the other bars are used.

Autoharp Score. In the music printed for the autoharp, a number and capital letter will be found indicated over each note. The number refers to the string and the point where, in sweeping a chord from left to right, one must be careful to finish each movement. These successive top notes not only complete each chord, but, in doing so, furnish the melody. The capital letter above each number in the music, showing which bar is to be pressed down with the left hand, has no reference to actual notes, the G major chord being usually labelled "C."

It is easy to arrange any simple tune which does not contain sharps or flats for the ordinary autoharp. Therefore, get a musical friend to transpose the top line of a hymn or other straightforward melody into the key of G. Then write above each note the number of its string on the autoharp, putting over the number the letter of the bar to be pressed down. The player's ear will guide him to the choice of the right bar. He will thus be able to furnish himself without expense with his own special stock of autoharp music. As an illustration of this, we give the charming old country tune known as "The Dusty Miller," the drone bass of which through-

Ex. 1



out is the tonic chord of G major [Ex. 1]. If the air is memorised at the piano, and then sung to the autoharp, all the player has to do is to press down the third bar (C), and continue sweeping the strings as an accompaniment to the voice, the left hand releasing the bar wherever an asterisk occurs, so as to admit of the notes not in the G chord being sounded by the right hand.

First, therefore, play each note, using only the "C" bar. When this can be done smoothly, change the harmonies by putting down the various bars at different times according to the letters indicated underneath the notes. The effect of concluding the tune with the relative minor chord of G and the relative minor chord of the subdominant (bars E and D) is quaintly appropriate. Make this final sweep (bar C) from right to left.

DULCIMER

The dulcimer is a flat, trapesium-shaped, double sounding-board, the upper one being perforated by a couple of sound-holes and provided with two bridges, across which the strings are stretched. Two, three, or more strings of brass, or steel, are grouped together and tuned alike to represent one note. On English instruments there are usually ten long notes, each one made up of several strings; and ten shorter notes.

Position and Tuning. The dulcimer is usually played standing. It should be placed on a table, slightly higher at the farther than the near side, so that the shortest strings, which are farthest away, may be manipulated as easily as the longest, in front of the player. Suitable tables are usually supplied with the dulcimer when it is sold, and care should be taken that the floor is level, so that the instrument may rest firmly.

The method of tuning the English dulcimer is to accord the group of strings nearest the player with the G below second ledger line, treble clef. The wrest pins are on the right of the player. Each one must be first threaded through the eye and a loop made at the other end of the string to fasten over the hitch pin on the left. Then with the tuning hammer, coil the wire carefully round the string to the right till the pitch is raised sufficiently. But get all the strings on first, the thickest towards the bass and the thinnest towards the treble, and draw them up slackly before attempting to get all to standard pitch. Watch the bridges and see that they keep even. The compass of the diatonic dulcimer, on which learners generally begin, comprises usually 22 notes, from the G named to the G, 4th ledger line above the treble staff, or three octaves in all. Having, with the help of a piano or harmonium, got the six lowest notes—G, A, B, C, D, E—in tune with the white notes on the keyboard, the student, observing that the compass extends from G to G, will doubtless conclude that the whole of it should be tuned to accord with G major, in which all the F's are sharp. But it is the custom with dulcimer players to tune the two lower F's natural, and only to have the top one sharp. This will be found a convenience, as the beginner usually starts with exercises in the key of C major. But different dulcimer players vary in their modes of tuning. The strings are numbered on the right from 1 up to 22, from the lowest to the highest note, unisons being grouped under one number.

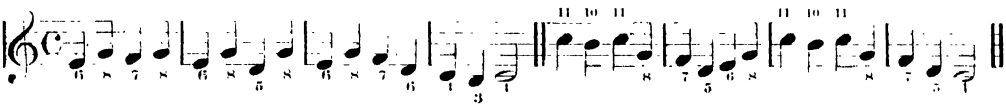
The Beaters. These are two sticks which are held in the hands as for playing the kettledrum, and require considerable elasticity of wrist to manipulate properly. The ends are provided with pads of leather, soft on one side and hard on the other, for use in getting "piano" or "forte" effects. All the different ways of right and left hand manipulation employed in tympani playing can be applied to the dulcimer. It is well to practise the various rolls with the sticks on the top of a wooden table, so as to get a greater facility apart from sound. It saves time and constant tuning, and can be practised almost anywhere. The general rule is to use the sticks as alternately as possible.

Rapidity in execution can be learnt most quickly by drum practice. But besides striking with regularity and velocity, the player must hit the right strings. In course of time, the diligent student will learn to do this automatically, and to graduate also the force of each blow, so that the beaters get crescendos and decrescendos of sound, and maintain the loudest or softest quality of tone, as marked in the music. But there is this peculiarity in dulcimer playing—which sets it apart from all other musical instruments and invests it with that savage attribute so dear to the hearts of the Magyars—the sound cannot be effectively shut off directly a note is struck, so that a confused jangle, to some ears, results, akin to playing on a piano with the "loud" pedal down the whole time.

Whether this effect is really unmusical is a matter for discussion, but it makes the dulcimer particularly interesting as the only link we have in this respect between Oriental and Occidental proclivities. Lest the absence of damping should set the musical mind of the beginner against the dulcimer, it is as well to note here that this instrument possesses considerable artistic possibilities. As far back as the end of the seventeenth century Habenstreit, of Eisleben, was a noted virtuoso on the dulcimer, and, since his day, many highly-gifted musicians have astonished and charmed large audiences by similar skill.

Key of C Major. Write out the scale of C major, beginning at C, 1st ledger line below staff, and continue it for two octaves, numbering the first C "4," and so on. Now, with alternate beaters, ascend and descend the scale, striking the notes in slow time, to the ticking of a clock or metronome, and with equal force, beginning softly and gradually increasing the strength as well as the speed. Having got the names and numbers of the notes well into the mind, a diatonic melody written for the voice in the key of C can be learnt without difficulty, although the student has had no musical training. Take, for instance, the melody known as the "Vesper Hymn." [Ex. 1.]

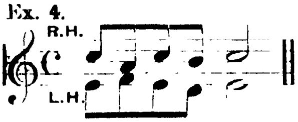
Ex. 1.



Ex. 2.

Ex. 3.

Ex. 4.



Having confined the rhythm to duplex time ($\frac{2}{4}$ or $\frac{4}{4}$), the beginner should next accustom himself to playing triplets. In this, on every fourth note, the accent is shifted from one hand to the other. [Ex. 2.]

Chromatic Dulcimer. The advanced student will endeavour as soon as possible to avail himself of an instrument giving the chromatic intervals. This is effected by a different disposition of the bridges, so that the vibrating length of the strings between the 1st and 2nd bridge, and the 2nd bridge to the tail pins, admits of different instead of the same sounds from one length of string. The longer stretch, on the right-hand side of the player, now produces the diatonic notes, whilst the shorter stretch on the left hand gives the chromatic sounds. The compass of the chromatic dulcimer is an octave less than the English instrument from G to G. It starts from C, 1st ledger line below staff, and goes to C, 2nd ledger line above it. But the intervening notes contain all the necessary half-tones to enable the instrument to be played in any key. Instead of C being No. 4, it now becomes No. 1, but the chromatic notes are always numbered with the diatonic, so that C and C♯ are both designated "1." Try the chromatic scale. [Ex. 3.]

The student can now begin to practise the scales in all the major and minor keys. After going up and down C major, sound the cadence given in Ex. 4.

Then go to G major. After transposing the cadence a fifth higher on paper, repeat it. Next go into D major, and so on through the different scales, until familiar with each key. Then tackle the minor scales. Endeavour to make the executive ability in manipulating the beaters keep pace with the facility required for reading.

So that ascending and descending runs in double notes may be executed rapidly and evenly, the ambitious student should practise scales in 3rds, 6ths, octaves, and 10ths, slowly at first, gradually augmenting the pace. The remarkable bravura capabilities of this instrument are shown in the Swiss dance (dated 1826) of the Canton of Appenzell, arranged for violin, dulcimer and 'cello, quoted in Sir John Stainer's "Dictionary of Musical Terms."

Mandoline, Banjo, Autoharp, and Dulcimer concluded

APPLIED CHEMISTRY

Chemistry and Commerce. The Chemical Industries. The Various Processes in Applied Chemistry. A Short Dictionary of Chemical Terms

By CLAYTON BEADLE and HENRY P. STEVENS

It is in the domain of pure science or pure research that great discoveries of industrial importance unexpectedly come to light. In such cases, the leading principle stimulating the chemist, the biologist, and the physicist is the love of knowledge for its own sake. When engaged in some particular investigation, the unexpected frequently happens, side issues arise which lead the investigator into fresh paths, and, although he may not attain the special object in view, his labours are not wholly disappointing. But such is not always the case, for many have worked and devoted a life of self-sacrifice without achieving any marked degree of success, and those who have striven for the attainment of some particular industrial object have, at times, failed utterly. But cases of failure may often be attributed to the lack of a proper combination of *theory* and *practice*. To perform a chemical operation in the laboratory is a very different thing from carrying it out on a large scale in the factory.

We shall endeavour briefly by way of introduction to refer to various operations performed, often unconsciously, by the chemist in the course of his analytical work, and at the same time common to most, if not to all, chemical industries.

Lixiviation. This is the separation of the soluble from the insoluble, as in the process of extraction by water. Example: soda recovery.

Extraction. In its general acceptance, this is the use of solvents, such as ether, alcohol, carbon, disulphide, benzene, petroleum, etc., as in the removal of fatty or greasy matters. Example: removal of wool fat from wool.

Subsidence, or Levigation. This consists in the separation of (insoluble) particles from watery solutions, etc., due to gravitation. The largest particles subside first, then the next in size, and so on, thus effecting the separation of (*a*) solid from solid; (*b*) solid from liquid; and sometimes (*c*) liquid from liquid. Examples: (*a*) clay washing; (*b*) clarifying effluents; (*c*) oil and water.

Levigation by Wet Grinding. This is the grinding of insoluble substances to a fine powder when wet, and separation by subsidence. Example: minerals for paints.

Evaporation. This is the removal of water either (*a*) "spontaneously," as under the influence of air, wind, sunshine, etc.; or (*b*) by the direct, or (*c*) indirect application of heat; or (*d*) by the use of vacuum pans with or (*e*) without heat.. Examples: (*a*) evaporation of salt from sea water, and the drying of hand-made paper; (*b*) soda recovery by Porion system; (*c*) "Stove," or table salt from brine; (*d*) concentration of sugar solutions and glycerine by multiple effect systems; and (*e*) drying of glue.

Distillation. This consists in the separation of a mixture of volatile and non-volatile (or less volatile) substances by the application of heat. Fractional distillation is applied to various liquids containing mixtures of substances having different boiling points, whereby one is separated from the other, the lower boiling constituents distilling over first.

Sublimation. This can be either spontaneous, as when snow disappears without melting, or induced by heat, as in the purification of salammoniac or naphthalene. It involves the direct conversion of a solid into a vapour, and, if necessary, its subsequent condensation again to a solid.

Filtration. This is the removal of solid impurities from liquids by passing or forcing the liquid through media such as cloth, paper, asbestos, sand, etc., which retains the solid and allows the clear liquid to pass, or the same operation as performed in the filter press for the purpose of separating out the waste liquid from the valuable solid matter which it may contain, or vice versâ.

Centrifugal force is taken advantage of as a means of separation, as in the centrifuge for removal of liquids from crystals.

Crystallisation. This is a means of separation dependent on the crystallising out of solids from liquid solvents, when the solutions are brought below their saturation point. The crystals may be removed by filter pressing, ladling, running off liquid, or by centrifuges. Examples: water softening, separation of lead and silver.

Calcination. This is the operation of heating solids without fusing them, or where only partial fusion takes place, as in the manufacture of cement, ultramarine, and the recovery of spent liquors. More or less synonymous terms are igniting, burning, firing, and roasting by means of the muffle out of contact of the fire gases and burning material.

In certain cases the material operated upon is sufficiently combustible to supply the necessary heat for its own calcination, as in the case of recovered ash by "rotary roasters."

Refrigeration. This is the use of cold to prevent or arrest chemical action, as with meat preservation, or to control bacterial growth, as in the case of lager beer fermentation.

Continued

SHORT DICTIONARY OF TERMS IN APPLIED CHEMISTRY

SEE ALSO SHORT DICTIONARIES ACCOMPANYING THEIR SPECIFIC SUBJECTS

ACIDIMETRY—The determination of the amount of acid in a substance.

Albumins or **Albumens**—A group of albuminoids soluble in water. Egg albumin (white of egg) is an example.

Albuminoids—Organic carbon compounds containing hydrogen, oxygen, nitrogen, and sometimes sulphur, and of very complex nature. They are essential both to animal and plant life.

Albuminoid Ammonia (in water)—Ammonia obtained by distillation with alkaline permanganate by Wanklyn's method.

Alcohol—Generally understood to mean ethyl alcohol, C_2H_5OH, a constituent of alcoholic beverages, and obtained by the fermentation of sugar. The term is also applied to substances of similar composition.

Aldehydes—Substances obtained by the careful oxidation of alcohol.

Alizarine—One of the colouring matters of madder (*Rubia tinctoria*), the other being purpurin. Also prepared artificially from coal-tar.

Alkalimetry—The determination of the amount of alkali in a substance.

Alkaloids—Bases obtained from plants and possessing highly poisonous or medical properties.

Alloy—An intimate mixture (possibly containing compounds) of metals with one another.

Alum—A double sulphate of alumina and another metal, crystallising in the regular system with 24 molecules of water. The name is often applied in commerce to sulphate of alumina alone.

Amalgam—An alloy of mercury with another metal or metals.

Amorphous — Without crystalline structure.

Aniline—A colourless oil obtained indirectly from coal-tar and belonging to the class of primary amines.

Aniline Dyes—Dyes obtained from aniline. The term is often incorrectly applied to all coal-tar dyes.

Animal Charcoal or **Bone Black**—A substance obtained by carbonising bones.

Animal Oil or **Bone Oil** — An oil obtained by distilling bones.

Anthracene—A white crystalline solid from coal-tar and the mother substance of the alizarine dyes.

Antichlor—Sulphites and other substances added to destroy any residues of chloride of lime left in a fibrous material after bleaching.

Antifebrin—Acetanilide; an antipyretic.

Antipyretic—Medicinal substance to allay fever.

Antipyrine—Phenyl-dimethyl pyrazolone; an antipyretic.

Apatite—A mineral phosphate and fluoride of calcium.

Aqua-fortis—Nitric acid.

Aqua-regia—A mixture of one part nitric acid and four parts hydrochloric acid.

Argol—Crude bitartrate of potassium.

Asbestos—A fibrous mineral substance used in making fireproof articles.

Ash—Mineral matter left on burning organic substances.

Asphalt—A natural mineral bituminous substance.

Aspirator—A machine to draw a current of air or other gas through an apparatus.

Assay—The determination of the quantity of a constituent contained in a substance.

-Ate—The termination of the names applied to salts of acids containing oxygen.

Autoclave—A digester or closed vessel in which liquids can be heated above their boiling points.

Azo—The group $N=N$ characteristic of a large number of colouring matters derived from coal tar.

BALSAMS—The exudations of plants consisting of resins, volatile oils, aromatic acids, and other substances.

Base—A metallic oxide or organic radical having the power of combining with an acid.

Basic—Having the properties of a base.

Bauxite—A naturally occurring hydrated oxide of alumina.

Beaker—A tumbler-shaped vessel of thin glass.

Benzaldehyde—Oil of bitter almonds: C_6H_5CHO.

Benzene—A liquid volatile hydrocarbon (formula C_6H_6) contained in coal-tar.

Bittern—The mother liquid that remains after common salt has crystallised out from sea-water.

Blacklead—Plumbago or graphite; a form of carbon.

Bleach or **Bleaching Powder**—Chloride of lime or calcium hypochlorite.

Blue-stone—Sulphate of copper.

Boiled Oil—Linseed oil which has been heated with litharge, manganese borate, or other substances, so that it has become thick and viscous.

Boiling-point—The temperature at which a liquid boils, the pressure being that of a normal atmosphere unless otherwise stated.

British Gum—*Dextrin*.

Bunsen Burner—Gas-burner having holes at the bottom for the admission of air.

Burette—A graduated glass tube provided with a stop-cock at the bottom for measuring fluids.

CALCINATION—The operation of ignition or heating till nothing but a mineral residue or calx remains.

Calc-spar—Native crystalline calcium carbonate.

Calibration—The process of ascertaining whether a vessel or other measuring apparatus holds or delivers the exact volume marked upon it.

Caliche—Impure native nitrate of soda or Chili saltpetre.

Calomel—Mercurous chloride.

Calorie—Metrical unit of heat, being the amount of heat required to raise one gramme of water 1° C.

Calorimeter—Apparatus for measuring heat, usually the amount of heat developed by substances when burnt.

Caramel—Brown colouring matter obtained by heating sugar or glucose.

Carbide—A compound of metal with carbon—as calcium carbide.

Carbohydrate—A compound of carbon, hydrogen, and oxygen, the relative proportions of the two latter elements being the same as in water—as sugar.

Carbolic Acid—Phenol: C_6H_5OH. A constituent of coal-tar.

Carbonyl—The group CO that is, a group composed of a carbon and oxygen atom in combination.

Carborundum—An extremely hard substance containing carbon and silicon.

Catalysis—The effect by which two substances are enabled to react in virtue of the presence of a small quantity of a third substance termed a *catalytic agent*.

Contact Action—A synonym for catalytic action. See *catalysis*.

Centinormal—One-hundredth of normal strength.

Chamber Acid—The crude sulphuric acid which collects on floors of the lead chambers; of a strength not usually exceeding 70 per cent. of pure acid.

Chili Saltpetre—Sodium nitrate.

China Clay—Kaolin, the purest variety of clay.

Chloride of Lime—Bleaching powder or calcium hypochlorite.

Cinnabar—Native sulphide of mercury or vermilion.

Cochineal—The body of a female insect which produces red dye-stuff.

Collodion—A solution of soluble nitro-cellulose in a mixture of alcohol and ether.

Colloid—A substance in the amorphous non-crystalline state—as india-rubber, glue, colloidal silica, cellulose.

Colophony—See *rosin*

Commercial Chemicals—Such as have not been specially purified.

Compound—A substance composed of two or more elements in combination with one another.

Condenser—Apparatus for condensing a vapour to a liquid, consisting commonly of a tube surrounded by a jacket of cold water.

Constitution—The mode in which elements are combined with one another in a compound.

Corundum—Native alumina or oxide of aluminium of the same composition as sapphire and ruby.

Creosote—Substance obtained by distilling wood or coal-tar.

Crucible—Cup-shaped vessel of fire-resisting material in which substances can be strongly heated.

Crude Product—Unpurified material obtained in chemical manufacture or laboratory work.

Cryolite—A native fluoride of aluminium and sodium.

Crystals—Characteristic geometrical shapes bounded by plane surfaces in which most solid substances occur, especially when separated from solution or on solidification.

Crystalline Systems—The six classes into which all known crystalline shapes are grouped.

DEAD OILS—The name applied to that portion of the coal-tar distillate which sinks in water.

Decantation—The process of pouring off the clear liquid after the solid matter has settled to the bottom.

Decinormal—One-tenth of normal strength.

Deliquescence—The absorption by a substance of moisture from the air, at times in sufficient quantities to cause it to liquefy.

Density—The mass of a unit volume of a substance. See also *specific gravity*.

Dephlegmator—A type of reverse condenser chiefly used in distilleries for freeing alcohol from water.

Desiccation—The process of drying.

Desiccator—As used in analytical work, a glass vessel with ground closely-fitting lid containing a hygroscopic substance such as calcium chloride, strong sulphuric acid or phosphorus pentoxide, so that any body placed inside rapidly loses its moisture and dries.

Dextrin—A gummy substance obtained from starch by the action of diastase.

Dextro-rotatory—Rotating the plane of polarisation of light to the right.

Dextrose—Grape sugar, a six-carbon sugar obtained from starch.

Diamines—Diamido compounds: compounds containing two amido (NH_2) groups or their derivatives.

Diastase—An unformed or soluble ferment which converts starch into sugar.

Digester—See *autoclave*.

Digesting—The process of heating together a solid and a liquid so as to give them every opportunity of reacting with one another.

Distillate—That portion which passes into vapour and collects in the receiver when a substance is distilled.

EFFLORESCENCE—Formation of a powdery deposit on crystals through loss of water or of a powdery crystalline deposit on the surface of a porous body, as in the case of nitre on the surface of the earth in India.
Electrolysis—Separation of a chemical substance into its constituents by an electric current.
Elementary Analysis—The determination of the proportions in which the elements are contained in a substance.
Elutriation—Washing a finely-powdered substance by repeated treatment with fresh water.
Endothermic Compounds — Compounds in the formation of which heat is absorbed.
Enzyme—Unorganised ferment.
Equivalent Weights—Weights of substances which will combine with or replace one part of hydrogen. The equivalent weight of a compound will be a simple fraction, usually one-half, of the molecular weight.
Ester—An ethereal salt.
Ether—Usually understood to mean ethyl ether. A highly volatile and inflammable organic liquid $((C_2H_5)_2O)$. The term is also applied to all substances of similar composition, and even to esters or ethereal salts.
Ethereal—Pertaining to ether; thus by an *ethereal* solution is meant a solution in ether.
Ethereal Salts—A salt of an acid in which the hydrogen is replaced by ethyl (C_2H_5) or other radicals, just as a metal replaces the hydrogen of an acid to form metallic salts.
Eudiometer—A gas analysis apparatus
Excess—A reagent is present in excess when more than sufficient has been added to react with the portion of a substance under examination.
Exothermic Compounds — Compounds in the formation of which heat is developed.
Extraction—Removal of one constituent from a mixture of substances by means of a solvent in which the remaining constituents do not dissolve.

FAT—Natural product composed of ethereal salts, such as glyceryl, stearate, palmitate, and oleate.
Fatty Acids—Acids formed on the saponification of fats. The generic term is now applied to several series of organic acids, including acetic and formic acids.
Fehling Solution—Solution of copper sulphate with Rochelle salt and caustic soda; used in testing for sugars.
Ferment—A nitrogenous organic substance with or without organised structure and power of reproduction.
Fermentation — Chemical process brought about by ferments.
Ferric or **Ferri Salts**—Salts of iron containing the trivalent iron atom.
Ferrous or **Ferro Salts**—Salts of iron containing the divalent atom.
Filtrate—The clear liquid obtained by filtration.
Filtration—The separation of a solid from a liquid by passage through a porous medium.
Flask—A globular-shaped vessel of thin glass.
Fluxing—Melting or fusing.
Foots—The deposit of impurities formed in the process of clarifying oils.
Forchammer Process—Determination of amount of acidified permanganate required to oxidise organic matter in a sample of water (water analysis).
Fraction—A portion of a distillate which has passed over during a definite range of temperature.
Free Acid—An acid not in combination with a base.
Free Ammonia (in water)—Ammonia, probably in combination as a salt, sometimes termed *saline ammonia*, and obtained by distilling the water with sodium carbonate.
Free Base—A base not in combination with an acid.
French Chalk—Steatite or soapstone. A hydrated magnesium silicate.
Fusel Oil—Fermentation amyl alcohol formed in small quantities during alcoholic fermentation.
Fusion Mixture—A mixture of equal parts of sodium and potassium carbonates, which fuses at a lower temperature than either separately.

GAS LIQUOR—An aqueous liquor rich in ammonium salts obtained in the purification of coal gas.
Glauber's Salt—Sodium sulphate.
Glucose—See *dextrose*.
Glucosides—Naturally occurring vegetable substances which split up on hydrolysis, yielding glucose and another substance which is not a carbohydrate.
Gluten—A sticky, nitrogenous substance obtained by washing out the starch from wheat flour.
Glycerine or **Glycerol**—An oily liquid with a sweet taste in reality an alcohol obtained by the saponification of natural fats and oils.
Gooch Crucible—One with a perforated bottom on which is a layer of asbestos so that the precipitate may be filtered, washed, and dried.
Grape Sugar—See *dextrose*.
Graphite—Blacklead; a form of carbon.
Gum—An amorphous carbohydrate characterised by its sticky properties and obtained from the natural exudations of plants.
Gun-cotton—Nitrocellulose obtained by treating cotton with a mixture of strong nitric and sulphuric acids.
Gypsum—Native crystalline calcium sulphate.

HALOGEN—One of the following four elements—chlorine, bromine, iodine, or fluorine.
Hardness of Water — The soap-destroying powder due to dissolved salts.
Homologues—Organic compounds of analogous composition to one another—for instance, methane, ethane, and propane are homologues.
Hydrate—A chemical substance having water in combination with it.
Hydrocarbon—A compound of carbon and hydrogen.
Hydrolysis—A type of chemical decomposition brought about by various agencies, but always accompanied by absorption of water.
Hydroxide—A compound consisting of a metal or radical in combination with hydroxyl groups—for instance, copper hydroxide $Cu(OH)_2$, alcohol or ethyl hydroxide $C_2H_5(OH)$.
Hydroxyl—The group (OH).
Hygroscopic Substance—One which absorbs moisture from the atmosphere.
Hypo—A prefix denoting a smaller proportion of oxygen.

INDICATOR—Substance used to indicate the completion of a reaction in titration processes — for instance, methyl orange.
Infusion—A liquid obtained by treating a vegetable substance with a solvent to dissolve out some of its constituents.
Inorganic Compounds—All compounds excepting those of carbon.
Isomeric Substances—Those having the same percentage composition, but different properties.
Isomerism—The phenomena exhibited by isomeric compounds.
-Ite—The terminal ending of names applied to salts of acids containing less oxygen than those ending in *-ate*.

KELP—The ash of certain seaweeds used as a source of iodine.
Kieselguhr—A porous silicious substance, with absorbent properties.
Kjeldahl Estimation—A method of determining nitrogen, especially in organic substances.

LACTIC ACID—An acid formed in the souring of milk by the action of a ferment on the milk sugar.
Lactose—See *milk sugar*.
Lævo-rotatory—Rotating the plane of polarisation of light to the left.
Lamina—A thin sheet or plate.
Laughing Gas—Nitrous oxide.
Leblanc Process—A method of making washing soda from common salt.
Lees—The deposit at the bottom of a vessel in which wine is fermented.
Lime—Calcium oxide obtained by burning limestone or calcium carbonate.
Liquation—The separation of bodies by heating and allowing the more fusible to melt and flow away.
Liquor—A general term applied to liquids containing dissolved matter.
Litharge—Lead oxide.
Litmus—A colouring matter obtained from a lichen and used as an indicator.
Logwood—The hard wood of a tree, which yields a red dye.
Lye—An alkaline liquor containing the caustic alkaloids or their carbonates.

MALTOSE, or **MALT SUGAR**—A sugar produced by the action of diastase on starch.
Marsh Gas—Methane (CH_4); the fire-damp of the miners.
Marsh's Test—A test for arsenic.
Measuring Flask—A flask which, filled to a mark on the neck, contains a measured volume of liquid.
Melt—A fused mass of crude product obtained by heating.
Mercuric Salts—Compounds of the higher oxide of mercury (HgO).
Mercurous Salts—Compounds of the lower oxide of mercury (Hg_2O).
Meta—A prefix used to distinguish one isomer from another.
Metal—An element which will combine with oxygen to form a base.
Methane—See *marsh gas*.
Methyl Orange—The sodium salt of an aniline dye; used as an indicator for strong acids.
Microcosmic Salt—Hydrogen sodium ammonium phosphate $HNa(NH_4)PO_4$.
Milk Sugar—A sugar found in milk.
Millon's Reagent—A solution of mercuric nitrate containing nitric acid.
Mineral Acid—This term usually includes sulphuric, hydrochloric, nitric, and other acids of inorganic origin.
Minium—See *red lead*.
Molecule—A word meaning little mass; the smallest particle of gaseous matter that can exist by itself.
Mordant—A substance used in dyeing to aid in fixing the dye on to the fibre.
Must—A crude liquor expressed from fruit.

NATIVE—Occurring in a natural state.
Nessler's Solution—A solution of mercuric iodide in potassium iodide, prepared according to a special recipe. It gives a yellow-brown colour, with even minute traces of ammonia, and a precipitate with larger quantities.
Nitre—Potassium nitrate.

Nitro-cellulose—Nitric esters of cellulose, such as gun-cotton.
Nitro-compound—One containing the nitro group (NO_2).
Nitrometer—A form of gas analysis apparatus used in the estimation of nitrous oxide in vitriol.
Nordhausen Sulphuric Acid—The fuming acid $H_2SO_4SO_3$.
Normal Acids and Alkalies—Solutions containing an equivalent weight in grammes of the substance in question dissolved in one litre of water at 15° C.
Normal Solutions—Solutions of standard strength based on a sytem of chemical equivalence.

OLEFINS—A group of hydrocarbons of general formula C_nH_{2n}, where n is any integer; for example, olefiant gas.
Organic Compounds—All compounds of carbon, with the exception of the monoxide and dioxide, which are usually reckoned as inorganic compounds.
Oxidation—The process of adding oxygen or subtracting hydrogen from a substance.
Oxide—A compound of an element or radical with oxygen.
Oxidising Agent—A reagent for adding oxygen to or withdrawing hydrogen from a substance.
Ozone—A form of oxygen containing three atoms to the molecule.

PARAFFINS—A group of hydrocarbons of the general formula C_nH_{2n+2}, where n is any integer; for instance, marsh gas (CH_4).
Pearlash—Calcined potassium carbonate.
Permanent Hardness—Hardness of water not removed by boiling, and generally due to the presence of dissolved sulphates.
Permanent White—Precipitated barium sulphate.
Peroxide—An oxide containing more oxygen than the common oxide.
Phenol—Carbolic Acid (C_6H_5OH).
Phenol-phthalein—An organic synthetic dye stuff used as an indicator for weak acids.
Pickling—A term applied to the process of soaking a solid in a liquid.
Pinch-cock—A spring clip for closing a piece of indiarubber tubing.
Pipeclay Triangle—A triangle clay pipe-stem held with iron wire, and used for supporting crucibles.
Pipette—Graduated glass tube for measuring liquids.
Plaster of Paris—Hydrated calcium sulphate or gypsum, from which part of the water has been removed.
Plumbago—Blacklead or graphite, a form of carbon.
Potash or Caustic Potash—Potassium hydroxide.
Precipitant—A substance used to bring about the formation of a precipitate.
Precipitate—A solid substance formed in a solution by a chemical reaction.
Proof Spirit—An antiquated and cumbrous standard of strength for alcohol. The density of proof spirit works out to ·91984 at 60° F. It contains 49·24 per cent. of alcohol by weight.
Proximate Analysis—The determination of the ingredients in a mixture of substances.
Prussian Blue—A pigment formed of complex cyanides of iron.
Pyrites—Native sulphides of iron, and of iron and copper.
Pyrolusite—A mineral containing crude oxide of manganese.

QUALITATIVE ANALYSIS—The process of ascertaining the nature of the constituents of a substance.
Quantitative Analysis—The process of ascertaining the proportions of the constituents of a substance.
Quartz—Crystalline silicon oxide or silica (SiO_2).
Quicklime—Calcium oxide (Cao).

RADICAL or **RADICLE**—A complex group of elements playing the part of, and reacting as, a single element.
Reaction—The chemical action of one substance on another.
Reagent—A substance, generally in solution, used to bring about a characteristic chemical reaction.
Red Lead or **Minium**—The oxide of lead (Pb_3O_4).
Reducing Agent—A reagent for adding hydrogen or abstracting oxygen from a substance.
Reduction—The process of adding hydrogen or withdrawing oxygen from a substance.
Reichert's Process—The standard method for estimating volatile fatty acids in butter.
Resin or **Colophony**—A resinous substance left in the retort after the distillation of crude turpentine.
Resins—A class of vegetable solids of brittle and glass-like fracture.
Rider—A small V-shaped wire which is shifted from one position to another on the beam of a balance, instead of putting weights into the pan.
Rochelle Salt—Sodium potassium tartrate.
Rock Crystal—Quartz.
Rock Salt—Native sodium chloride or unrefined common salt.
Rouge—Finely ground ferric oxide (Fe_2O_3).

SALINE—Partaking of the nature of a salt.
Saline Ammonia (in water). See *free ammonia*.
Salt—Generic term for the product of the combination of an acid with a base.
Salt Cake—Crude sodium sulphate; the first stage in the manufacture of soda by the Leblanc process.
Sampling—The operation of removing a small portion or sample representative of the whole.
Sand Bath—A shallow metal tray containing a layer of sand on which vessels may be heated.
Saponification—The process by which a soap (metallic salt of a fatty acid) is obtained from a fat. The term is applied also to the hydrolysis of any ethereal salt with the formation of an alcohol and a fatty acid or its salt.
Saturated Solution—A solution containing as much substance dissolved in it as the liquid will take up.
Semi-normal—One half of normal strength.
Silicious—Composed of, or partaking of the nature of, silica or sand.
Slag—A fusible silicate formed in the process of obtaining metals from their ores.
Slaked Lime—Lime slaked; that is, treated with sufficient water to form calcium hydroxide.
Smelt—Cobalt blue. A silicate of cobalt.
Soap—The metallic salt of a fatty acid, generally oleic, palmitic, or stearic, or a mixture of these.
Soda Lime—A mixture of soda and lime, used for absorbing carbon dioxide gas.
Soft Soap—A potash soap or potassium salt of a fatty acid, hard soaps being sodium salts.
Solvent—Liquids used for dissolving substances.
Soxhlet Apparatus—An automatic apparatus for the extraction of fatty substances with volatile solvents.
Specific Gravity—The ratio of the weight of a substance to the weight of an equal volume of water.
Standard Solution—Solution of definite strength, usually normal or decinormal.
Steam Oven—An oven surrounded by a steam jacket.
Still—Distilling apparatus.
Suction Gas—See *water gas*.
Sulphonic Acid—An organic acid containing the group SO_3H.
Superphosphate—A manurial substance containing monocalcium phosphate.
Synthesis—The building up of a compound from its elements, or from simpler substances.

TALC—A substance of similar composition to French chalk.
Tartar Emetic—Potassium antimony tartrate.
Temporary Hardness—Hardness of water removed by boiling, and due to bicarbonates. See also *hardness*.
Thermometric Scales—Those commonly used are the Centigrade and Fahrenheit scales.
Thio—A prefix showing that oxygen in the substance has been replaced by sulphur.
Tincal—Crude borax.
Titration—The process of adding a measured amount of a solution of one substance to another until the reaction between them is complete.
Turmeric—Yellow colouring matter.
Twaddell Degrees—A technical method of reckoning the specific gravity of a liquid. Thus, Degrees

$$\text{Twaddell} = \frac{\text{specific gravity} - 1{,}000}{5}$$

water = 1,000

ULTIMATE ANALYSIS—The separation of substances into their constituent elements.
Ultramarine—An artificial blue colouring matter resembling ground lapis lazuli.
U-tube—Glass tube in the shape of the letter U, and used for absorbing gases.

VACUUM DESICCATOR—A desiccator from which the air can be exhausted.
Valency—The combining capacity of an element or the number of hydrogen atoms or their equivalents with which an atom of the element in question will combine.
Vermilion—Sulphide of mercury; used as a pigment.
Vitriol—Sulphuric acid.

WASH-BOTTLE—Bottle or flask with which a jet of water can be directed on to a precipitate for the purpose of washing it.
Washing—Treating a substance (usually a precipitate) with successive quantities of a solvent, such as water, in order to dissolve soluble impurities.
Water Gas—A mixture of hydrogen and carbon monoxide gases obtained by passing steam over red-hot coke.
Water Oven—*Steam oven*.
Wax—An ethereal salt of a fatty acid, and a monohydric alcohol (alcohol with a single hydroxyl group).
Weighing-bottle—A small stoppered bottle in which a substance can be weighed out of contact with the surrounding air.
Welldon's Process—A process for the recovery of manganese from still liquors, and hence indirectly a method for making chlorine.
White Arsenic or **Arsenic**—Arsenic oxide (As_2O_3).
White Lead—Basic carbonate of lead.

YEAST—A vegetable (organised) ferment which is capable of converting sugar into alcohol.

ZINC WHITE—Zinc oxide (ZnO).

A FIGHT FOR THE WORLD'S CROWN

France in the Middle Ages—continued. Mediæval Italy. The Struggle between Pope and Emperor. The Rise and Fall of Rienzi. A Great Period of Art

By JUSTIN McCARTHY

IN 1590 Henry won a victory over the Leaguers, under the Duke of Mayenne, at the famous battle of Ivry, and in 1593 succeeded to the throne, having in July of that year professed himself a Catholic, the profession being celebrated with great pomp at St. Denis. In 1598 a peace was concluded between France and Spain, who had been at war for a long time, and in the same year Henry signed the famous Edict of Nantes, by which he secured to the Protestants liberty of conscience and equal treatment by the law.

The Famous Henry of Navarre. Henry had already proved himself one of the great warrior princes of France, and he now showed that he had high qualities for civil government. When he came to the throne, the landed aristocracy managed the affairs of the provinces according to their personal will and after the most arbitrary fashion as regarded the imposition of taxes and compulsory service. Henry threw his heart into these questions, and accomplished many splendid reforms. He instituted also a system of road-making, by which he opened up all parts of his kingdom to business enterprise and traffic, and thus developed industry and prosperity throughout France.

In his great work of reform Henry was well supported by his minister, Maximillian, Duke of Sully. Sully had accompanied Henry in his flight from the French Court; had gone with him afterwards into his wars; had proved himself a brilliant soldier, and helped to win victory at Ivry, and other battles. Sully set himself at once to repair the ruined financial system of the State. Within ten years he reduced the National Debt to less than one-sixth of what it represented when he took charge of the national exchequer. During his time, he raised the revenue of the State to more than double its annual amount, while he took care that the navy and war departments were put into a satisfactory working condition. The great reign of Henry came to an end on the 14th of May, 1610. He was murdered by a man named François Ravaillac, who had been a schoolmaster, had become bankrupt, and, after long imprisonment, had joined a monastic order. It is believed that Ravaillac was driven by fanaticism to kill the sovereign who was giving religious liberty to his subjects. It has been well said by a French historian that Henry was the greatest, and, above all, the most essentially French of all the sovereigns of France.

International Arbitration. Among some of his projects was the idea, revived at intervals since his time, of a confederation of European states, at which all international questions should be settled by inquiry and arbitration, without an appeal to arms. Like many other great soldiers, he was at heart a lover of peace, and was filled with a conviction that an international tribunal could be formed by whose careful consideration and judicious decisions reason and equity could be made to triumph, without the uncertain services of the sword.

ITALY

Italy remained for centuries in a condition of almost incessant civil war among a number of rival states such as Rome, Venice, Milan, Naples, Sicily, and others—when the Italians were not engaged in endeavouring to repel invaders from their own shores

In 800, Pepin, the son of Charlemagne, was crowned Emperor of the Romans, and another descendant of Charlemagne, Louis II., came to the aid of Pope Leo IV. against the Saracens, and, for a time, checked their progress. Eight kings of the Carlovingian line were acknowledged in Northern Italy, but their rule ended in 887, and they were followed by ten Italian kings—kings in name, at least—dukes of different parts of Italy. In 961, Berengar II. was deposed, and Otto of Saxony was crowned King of Italy at Milan and Emperor of Rome at Rome. From that time the Crown of the Roman Empire, later called the Holy Roman Empire, was claimed by the sovereigns of Germany for many centuries.

During all these long struggles Rome had continued to be the seat of the Papal power; but even the power of the Popes had not been able to secure the great city as their permanent place of residence during the whole of the Middle Ages, for in 1307 the Papal Chair had to be removed to Avignon, in France, where it remained until 1370, when it was restored to Rome by Pope Gregory XI.

The Papal Fight for Temporal Power. Throughout the Italy of the Middle Ages two great forces dominate, forces which, in the eyes of the idealists of the time should unite to govern the world, forces which, as a matter of fact, were mostly set in steady opposition. These two forces were the Pope and the Emperor. The heir of Peter and the heir of Cæsar strove for the world's crown instead of guarding it with the sword and the keys. The conflict of these great chiefs split all Italy into two great factions, they themselves afterwards subdividing by different political and local causes in very bewildering fashion. The struggle of the Guelphs and the Ghibellines contributes much to the most fascinating history of mediæval Italy. Though the names of the two factions are now always associated with Italy, they had their origin in Germany. That country, steadily conquering portion after portion of the Roman Empire, gave to subjugated Europe an aristocracy of

German names, and gave to Italy besides the names of the two great parties whose feud rent every Italian city and divided many an Italian household.

The Wars of the Two Factions. Otto of Freising, writing of the middle of the twelfth century says, "Up to the present time two families have been famous in the Roman Empire, about the parts where Gaul and Germany meet—the Henries of Waiblingen and the Welfs of Altdorf." The name of the little town of Waiblingen and of the family of Welfs were Italianised into the forms we now know as Ghibelline and Guelph. Through the perplexing and intricate history of mediæval Italy, with its many independent cities and little principalities all warring one with another, these two names of faction are ever to the front. It is not easy to estimate precisely what the two terms signify. Speaking roughly, the Ghibellines stood for stern authority and the Guelphs for popular liberty; but the exact significance of the terms varied under varying conditions. Broadly, the Ghibellines were the party of the Emperor, and the Guelphs the party of the Pope. A hostility that dawned with the expedition of Frederick Barbarossa against Italy in 1154 persisted through the ages, and its influence is perhaps not yet altogether extinct.

While Pope Innocent III. was giving the law to every kingdom of Europe; while the Emperor Frederick II. was the most brilliant figure in his brilliant Court, and was coming under the excommunication of Guelphic pope after Guelphic pope; while from Frederick's death in 1250 to 1309 no Emperor was recognised in Italy, the Guelphs and the Ghibellines continued to rage against each other.

The Dream of Rienzi. During the years when the Papal seat was at Avignon was seen the rise and fall of Cola de Rienzi. This remarkable man was born of humble parents, in 1313, but was from his childhood an eager student of the great Latin Classics, and he became filled with a passionate desire to restore the Roman people to their ancient position of independence and glory. He found Rome suffering under an aristocratic rule during the intervals of its invasions and captures by foreign powers. The death of his brother by the wanton act of a noble, and the knowledge that he could obtain no redress, gave a sudden stimulus to his revolt against the power of the nobles. In 1347 he succeeded in inducing the citizens of Rome to rise against the aristocratic Senate. The Senatorial rule was for the time completely overthrown, and Rienzi was made Tribune, a position which was practically that of Dictator. He endeavoured to bring about the realisation of that dream which was yet to remain a dream for some centuries—the unity of Italy, with Rome for its centre of government.

He prevailed upon the other states of Italy to send delegates to Rome to consult on measures for the construction of a great Italian confederation. The scheme was received with enthusiasm, and on August 1st, 1347, two hundred deputies assembled in the Lateran Church, and Rienzi was crowned Tribune of the new Federation on April 15th. But the delegates, like Rienzi himself, had been carried away by enthusiasm, and had not estimated the immense power of the aristocrats. Rienzi defeated the nobles in a bloody battle in November, but, filled with the pride of victory, he tried to enforce obedience, and became unpopular. The Pope declared against him, and after only seven months of his exalted position the bright dream faded, and the Tribune had to seek refuge in Naples, where he remained for two years leading a life of religious seclusion.

A Failure due to Success. He then determined to go back to Rome and continue his efforts for the overthrow of the nobles. He first went to Prague to ask the support of the Emperor Charles IV., but was sent by him as a prisoner to Pope Clement VI. By the intercession of Petrarch he was released, and the new Pope, Innocent VI., who had succeeded, wishing to crush the nobles, sent Rienzi to Rome with Cardinal Albornoz. Now might have come the triumphal hour of the people's Tribune. But Rienzi seems to have been carried away, for the first time, by personal ambition, and his second success led him into the desire to win for himself a supreme position. He formed a body of soldiers into a guard of his own, and headed a procession into Rome in August, 1354 His general bearing seems to have convinced a large number of Romans that he was an ambitious self-seeker rather than a devoted patriot; where he was once adored he was now detested, and in a sudden burst of fury a number of the populace surrounded his house and put him to death.

The career which had opened so brilliantly came to this ghastly end on October 8th, 1354, when Rienzi had hardly passed his prime. There can be no question that he was a man of great ability and force of character, and that he had then dreamed a dream for that unity of Italy which has in our days become a living reality. In 1370, Gregory XI. restored the Papal throne to its place in Rome.

The Times of Dante. The years at which we have been taking a rapid glance form a period during which some of the greatest names in Italian art and letters came into their full lustre. Dante Allighieri, one of the great poets of all time, was born in Florence, in 1265. In 1289 he took part in the battle of Campaldino, but he seems soon to have given up military life for politics, in which he sided with the Guelph party. When that party later became divided into Blacks and Whites, his sympathies were with the Whites, or more moderate Guelphs. When the Blacks triumphed, Dante and others—among them the father of Petrarch—were exiled from Florence, in 1302. Dante went first to Verona, then to other parts of Italy, and, it is said, to Paris, and finally to Ravenna, where he died on September 4th, 1321, and was buried by his friend Guido. Of his many works those best known to English readers are the "Divine Commedia" and the "Vita Nuova," which tells of his love for Beatrice

Petrarch, another great Italian poet, was born in Arezzo, in 1304. He lived for many years at Vaucluse, near Avignon, during the years when the Papacy was established at Avignon, and it was there that he first met the Laura to whom his famous sonnets are addressed. He died in Italy—at Arqua—in 1374. There were other great names in literature and, of course, very many in painting and sculpture, which arose in Italy during succeeding generations, but those of Dante and Petrarch will vindicate the claims of the Italy of the Middle Ages to rank with the Italy of the days of Virgil and Horace.

Italy under Five Rulers. The history of Italy now becomes for a long time a narrative of the struggles between rival rulers and families at home for the possession of Italian regions which had been lost, or for further conquests. The Italian peninsula was divided among five different rulers. The Kingdom of Naples, the Duchy of Milan, the Republics of Florence and Venice, and the Papacy at Rome held the country as independent powers. The states were, however, not held continuously by the same line of rulers, for there were frequent changes of masters. Venice was ruled for the most part by a hereditary Grand Council, and her long contest with Genoa to become the ruling power of the Mediterranean had ended in success for Venice. The Emperor Charles V. of Germany, and Francis I. of France, rivals in their efforts for power in Italy, kept the country long distracted.

The Sack of Rome. Francis regained possession of Milan in 1515, but some years after the Emperor was again successful; in 1524 he drove the French forces out of Italy, and during the long struggle the French King was actually taken prisoner at Pavia. The sack of Rome by an army made up chiefly of Lutherans and Spaniards, fighting for the Emperor, and the foreign occupation of Rome, lasted for several months, and distracted the great historic city by successive and horrible scenes.

The family of the Borgias, which was one of the most powerful in mediæval Italy, came originally from Spain. Alfonso de Borgia, a bishop, accompanied Alfonso of Aragon, whose secretary he was, to Naples. Later on he was chosen as Pope, with the title of Callixus III. His nephew Rodrigo became Pope in 1492, as Alexander VI. Before he ascended the Papal chair he was the father of many children, of whom Cæsar, his fourth child, and Lucrezia, his fifth, were the most famous. Cæsar Borgia was born in 1476 and died in 1507. His active life lasted only about four years. His ambition was to reconstruct a Kingdom of Central Italy, of which he should be the head; and it seemed for a time as if he would succeed. But the death of his father in 1503—it was believed by poison—was fatal to Cæsar's plans. Pope Pius III. was succeeded by a great enemy of Cæsar's—Pope Julius.

Cæsar was imprisoned in 1504, but escaped two years later, and went to Navarre, where he was killed while in command of the Royal forces in the following year at the age of thirty. About him was written Machiavelli's famous "Principe." He was a lover of art and letters, and the patron of Lionardo da Vinci.

The Medicis. During the fifteenth century the family of the Medici had become practically the rulers of Tuscany. With Cosimo de Medici (1389-1464) began the glorious epoch of the family. He obtained for Florence, which was still—at least nominally—a Republic, a temporary safety from invasion and something like peace from civil strife. He devoted much of his time and wealth to the encouragement of letters and art; he adorned the city with magnificent buildings, and established some great libraries. He was the grandfather of the famous Lorenzo de Medici, called "The Magnificent," most famous as the patron of Michelangelo.

To a younger branch of the family belonged the next important ruler of Florence, Cosimo I., who at one time enjoyed the distinction of the title of "The Great." Cosimo had much ability, energy, and statesmanlike capacity, and had inherited the love for literature and art of some of his predecessors. He was, on the whole, a just ruler, though in his personal dislikes he was severe and capricious. He was made Grand Duke of Tuscany in 1570, and was crowned by Pius V. He died four years later.

Continued

MACHINE DETAILS

Cams. Spindles. Thrust Bearings. Footstep Bearings. Ball Bearings. Roller Bearings. Detail Sketches

Group 8
DRAWING
30

TECHNICAL DRAWING continued from page 4206

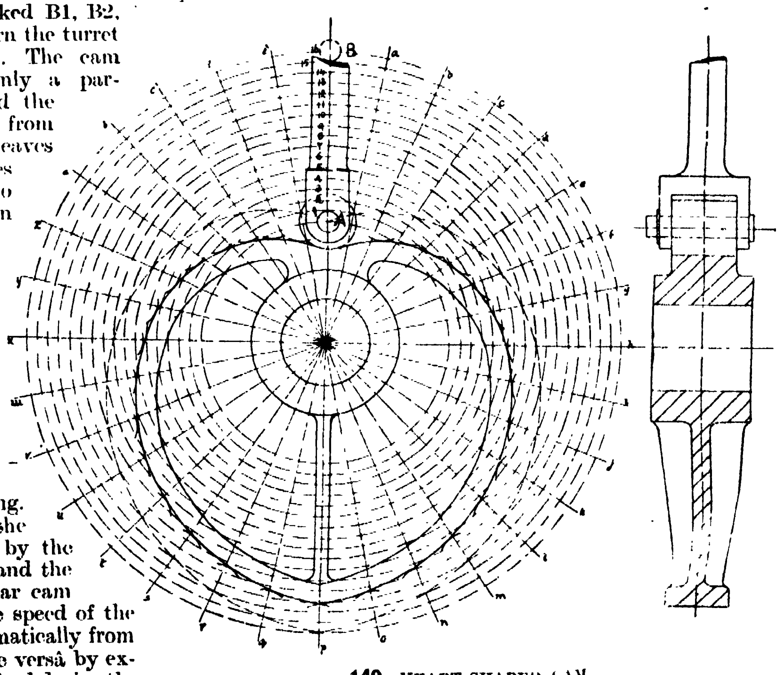
By JOSEPH W. HORNER

Cams. After the detail drawing of the frame of a machine has been completed, the minor details are drawn out on separate sheets as previously explained. Fig. **141** illustrates a working detail drawing of the cams of an automatic screw machine. The views shown comprise a separate detail of each cam and a general lay-out of the cams upon the drum which carries them. The drum is circular, but its periphery is developed in order to figure thereon the exact measurement for spacing the cams. The turret of the automatic machine described on page 3632 in MECHANICAL ENGINEERING is controlled by a series of cams somewhat similar to those we now illustrate in **141**. The cams are of tempered spring steel, and are secured to the drum by means of ½-in. screws; the working face of each cam has a bevelled edge arranged so that the turret roller may clear the face of the drum and yet have complete contact with the cam. The drum is 30 in. diameter, the length of its periphery or circumference is therefore 94·248 in. The width of the drum is 10 in., which allows for a total travel of the turret of 9¼ in. A line marked zero is the base from which all measurements are taken when spacing the cams around the drum.

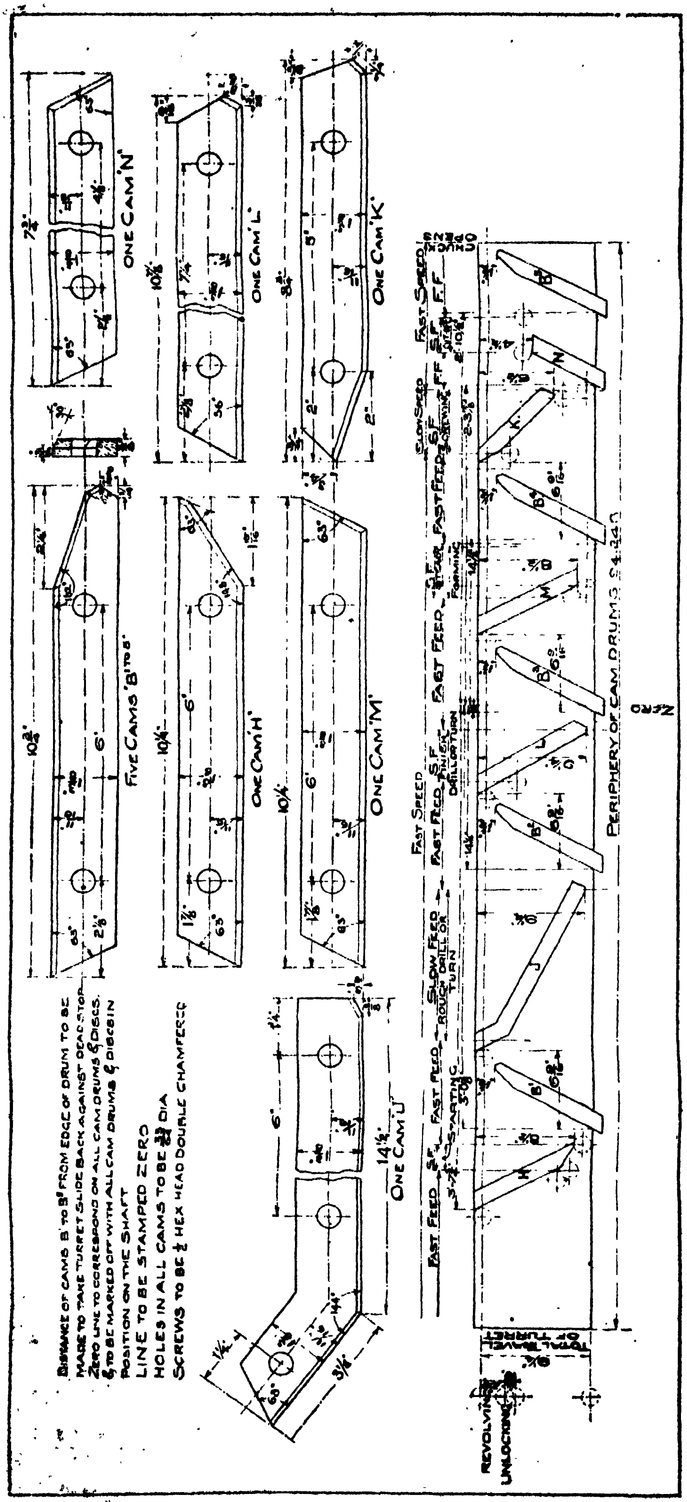
The cams marked H, J, L, M, and K are used for feeding the turret forward for various operations, while the cams marked B1, B2, B3, B4, and B5 return the turret from the operations. The cam marked N gives only a partial return feed, and the turret is stationary from the time cam N leaves it until cam B5 catches the turret roller to complete the return feed. This period is taken up by the cutting off of the finished screw from the stock bar in the chuck. There is a somewhat similar period of rest between cam M and cam B4, which is taken up by the forming tool coming into action and retiring.

The speed of the turret is governed by the speed of the drum and the angle of the particular cam in engagement. The speed of the drum is varied automatically from fast to slow and vice versâ by external means as required during the revolution; the slow speed is used while a screw is being actually machined, the other cutting operations being performed, at fast speed. All the return-feed cams, B1 to B5, are set at an angle of 63 deg. for quick return, while some of the forward feed cams, U in particular, have a very much smaller angle, and consequently feed considerably slower; in fact, the angle of the cam is designed to suit the rate of feed, and this is determined by the nature of the work to be done by the active tool in the turret. The duty of each cam is stated on the general lay-out. The illustration [**141**] is reproduced from an actual working drawing supplied by Messrs. Alfred Herbert, Ltd., Coventry.

Heart-shaped Cam. The cams in the preceding example are single acting—that is, they do not separately complete the reciprocal movement of the turret. In many mechanisms it is essential that a single cam shall complete a forward and backward stroke, when it takes the form of a revolving plate properly shaped to give the required movement. Fig. **140** shows a heart-shaped cam, designed to give a uniform reciprocating motion to a vertical rod. To mark it out properly, we first consider the path to be traced by the centre of the roller which is on the rod. Draw circles for the shaft and the boss of



140. HEART-SHAPED CAM



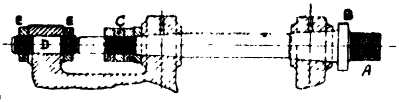
141. CAMS FOR AN AUTOMATIC SCREW MACHINE

the cam, lay off the thickness of the cam rim above the boss, which thickness may be one-quarter the diameter of the shaft, and then describe the roller and its rod. The stroke or travel of the rod A B is measured off and divided into any given number of parts (say 16), dotted circles are drawn through these points, as shown, using the shaft centre as a common centre; then divide the circumference of the outer circle into 32 equal parts, *a*, *b*, *c*, etc., and draw radial lines to the centre. The theoretical curve of the cam passes through the intersections of 1*a*, 2*b*, 3*c*, 4*d*, 5*e*, and so forth, such a curve being the true path of the roller centre. To obtain the actual outline of the cam, a series of arcs are struck from the intersections, the radii of the arcs being the radius of the roller. A line touching all these arcs and having a smooth curve is the outline required.

Small cams are frequently formed from flat sheets of metal, but large ones are made with rims and ribs as **140**. The outlines of cams can be varied to give variable speeds, periods of rest, slow speeds, and quick return motions, etc. In *crushing machinery* cams are often used to lift a weight, which drops freely when the apex of the cam leaves it. In such cases the cam has no return face.

Spindles. Spindles are small shafts, used in machine tools and light machinery. They are generally short, and have special provision for adjustment and lubrication. Fig. **142** shows a spindle as fitted to a lathe headstock. The front end, A, is screwed to receive the faceplate, and a collar, B, is made part of the spindle in order to stop the faceplate always in the same position. The coned necks in the two front bearings are arranged so that when wear takes place the necks may be drawn into the bearings and the slackness taken up without lowering the centre of the spindle. The back lock nuts, C, are for

drawing the spindle into the bearings ; the back cone is smaller than the front cone so as to pass through the front bearing. The third bearing carries a stop pin, D, the function of which is to prevent the conical parts from jamming in the bearings when end thrust occurs. It is fitted with adjusting nuts, E. The taper of the cones may be from 1 in 4 to 1 in 6, measured on the diameter.

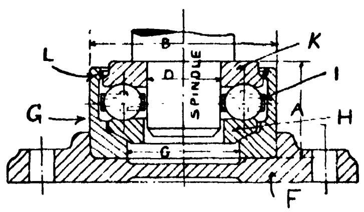


142. LATHE SPINDLE WITH CONES

Another spindle is indicated in **143**, where end thrust is taken in a *thrust bearing.* A number of collars are turned on the spindle to fit into a corresponding number of recesses in the back bearing ; both the front and the back bearings are divided and fitted with caps, so that adjustment can be made for wear. The bearings are parallel, and lock nuts, A, are provided for the purpose of taking up wear on the faces of the thrust collars. This is a common form of spindle on heavy lathes where the end thrust is considerable.

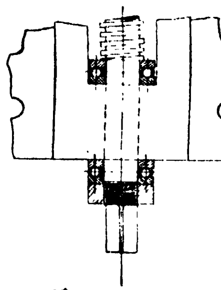
143. LATHE SPINDLE WITH THRUST COLLARS

Thrust Bearings. The most efficient thrust is that made with steel balls, for in such construction rolling friction takes the place of sliding friction. Fig. **144** illustrates a ball-thrust bearing arranged at the bottom end of a vertical spindle. This is made by the Hoffmann Manufacturing Co., Chelmsford. The construction is simple and entirely self-contained ; the baseplate F can be made to suit any machine, or it may be part of a machine. The ball thrust proper is composed of an outer cast-iron casing, G, recessed into the baseplate F ; a cone or floating disc, H, which automatically adjusts itself in its seating and so ensures an equal load upon all the balls ; a ring of balls held in a retaining cage, I, a hardened steel cup, K, and a retaining wire, L. The retaining cage I prevents any friction between the balls themselves ; it is so designed as to float upon the balls, and therefore it does not bear upon either the cup K, the cone H, the casing G, or upon the spindle itself to cause friction. The retaining cage also enables the complete ring of balls to be handled without the balls falling out, a great convenience when putting a bearing together or dismantling. The retaining wire L keeps all the parts together. It is not necessary to key either the cone H or the cup K in place, as the friction between them and the balls is so slight that the friction between them and their seats is ample to prevent rotation. The steel balls are "Hoffmann balls," and are guaranteed to be within one ten-thousandth part of an inch of standard, both as to sphericity and size. These bearings do not provide for side support of the spindle, but only for end thrust ; they are made in heavy, medium, and light types. A table of sizes of the medium type is given on page 4327.



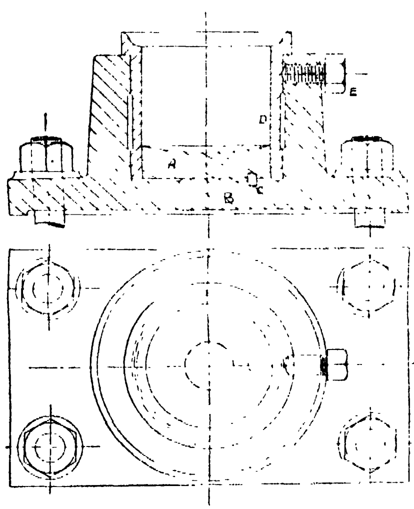
144. BALL-THRUST FOOTSTEP BEARING

Footstep Bearing. An ordinary footstep bearing is shown in **146**, which provides for end thrust and also for side support of the spindle, but is not so efficient as the previous example. The thrust is taken upon a concave steel disc, A, laid upon the baseplate B, and kept from turning by the pin C : the disc A is kept in a central position by the gunmetal bush D, which bush also gives side support to the spindle ; the set screw E keeps the bush from turning.

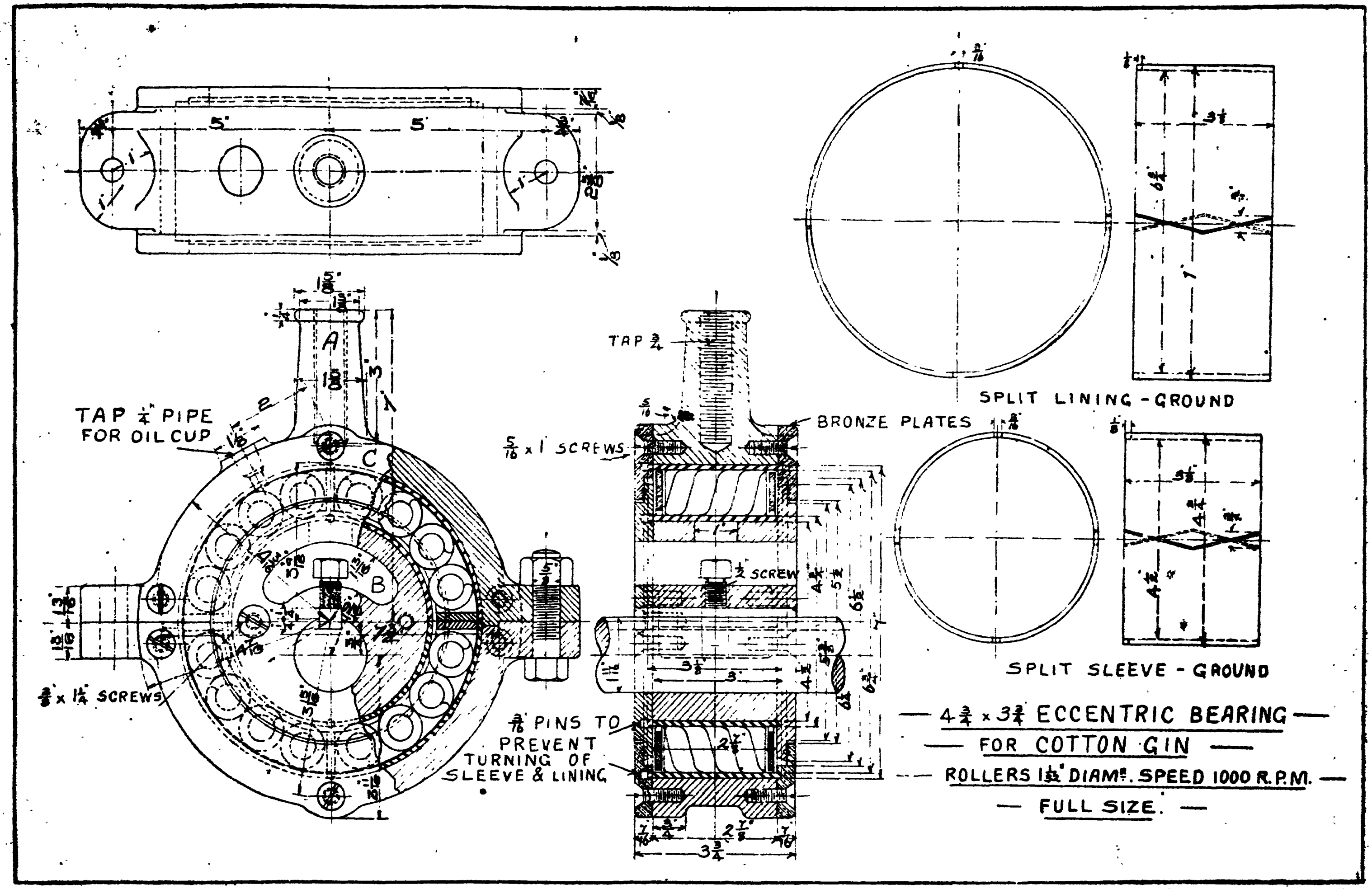


145. BALL-THRUST WASHERS

Ball-thrust Washers. A common device to take end thrust on light spindles is to have several washers arranged between the end bearing and a collar on the shaft. A better method is illustrated in **145**, which shows an application of two Hoffmann ball-thrust washers to the feed screw of a lathe slide. The ring of balls is held in a retaining cage as in **144** ; hardened steel washers are provided for the balls to run between ; these bearings are made with a hole five-thousandths of an inch larger than standard, so as to allow the spindle to revolve freely inside the washer. The end of the spindle is screwed and fitted with a circular nut, which is kept from revolving by a pin passing through both nut and spindle.



146. PLAIN FOOTSTEP BEARING

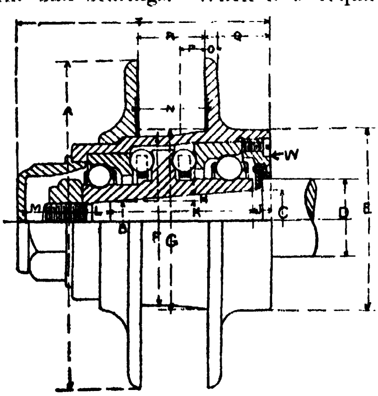


147. ECCENTRIC ROLLER BEARING (Hyatt Roller Bearing Co., Ltd.)

HOFFMANN THRUST BEARINGS—MEDIUM TYPE																
Sizes .. .. in.	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6
Size of balls .. in.	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
Number of balls ..	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
H'ght of bear'gs A. in.	$\frac{27}{32}$	$\frac{29}{32}$	$\frac{29}{32}$	$1\frac{1}{16}$	$1\frac{3}{16}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{11}{16}$	2	$2\frac{5}{16}$	$2\frac{5}{8}$	3	$3\frac{1}{4}$	4	$4\frac{5}{8}$	$5\frac{1}{4}$
Outside diam. B. in.	$1\frac{3}{4}$	2	$2\frac{1}{8}$	$2\frac{3}{8}$	$2\frac{5}{8}$	3	$3\frac{1}{2}$	$3\frac{7}{8}$	$4\frac{1}{2}$	$5\frac{1}{8}$	6	$6\frac{7}{8}$	$7\frac{3}{4}$	9	$10\frac{1}{4}$	12
Bore of case C. in.	1	$1\frac{3}{16}$	$1\frac{5}{16}$	$1\frac{1}{2}$	$1\frac{11}{16}$	2	$2\frac{5}{16}$	$2\frac{5}{8}$	3	$3\frac{3}{8}$	4	$4\frac{5}{8}$	$5\frac{1}{4}$	6	$6\frac{3}{4}$	8
Shaft diameter D. in.	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6

HOFFMANN BALL-BEARING HUB—HEAVY TYPE								
Size of Bearings		$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{9}{16}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$
Diam. of large journal balls		$\frac{1}{2}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$
,, ,, small		$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
,, ,, thrust balls (2 rows)		$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
Number of balls in each row		10	10	10	10	.10	10	10
Diam. of flange	A. in.	$6\frac{1}{4}$	$7\frac{1}{4}$	$7\frac{5}{8}$	$8\frac{1}{2}$	$9\frac{7}{8}$	11	13
,, ,, axle, small end	B. in.	$\frac{3}{4}$	$\frac{7}{8}$	$1\frac{1}{16}$	$1\frac{5}{32}$	$1\frac{5}{16}$	$1\frac{1}{2}$	$1\frac{5}{8}$
,, ,, ,, large end	C. in.	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{9}{16}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$
,, ,, ,, body	D. in.	$1\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$
,, ,, end of housing	E. in.	$3\frac{1}{2}$	$4\frac{1}{4}$	$4\frac{7}{16}$	5	6	$6\frac{3}{4}$	$7\frac{1}{2}$
,, ,, body	F. in.	$3\frac{1}{4}$	$3\frac{3}{4}$	$4\frac{1}{8}$	$4\frac{9}{16}$	$5\frac{3}{8}$	$6\frac{1}{4}$	7
,, ,, taper	G. in.	$3\frac{7}{16}$	$4\frac{3}{8}$	$4\frac{3}{8}$	$5\frac{1}{8}$	$5\frac{7}{8}$	$6\frac{1}{2}$	$7\frac{1}{4}$
Degrees of taper on shaft ..	H. ..	4°	4°	4°	4°	4°	4°	4°
End of cone to end of housing ..	J. in.	$\frac{11}{32}$	$\frac{13}{32}$	$\frac{13}{32}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{9}{16}$
Length of taper inside cone ..	K. in.	$2\frac{11}{16}$	$3\frac{37}{64}$	$3\frac{37}{64}$	$4\frac{1}{4}$	$4\frac{59}{64}$	$5\frac{23}{64}$	$6\frac{1}{4}$
,, ,, straight part inside cone	L. in.	$\frac{33}{64}$	$\frac{7}{64}$	$\frac{29}{64}$	$\frac{13}{64}$	$\frac{9}{64}$	$\frac{27}{64}$	$\frac{7}{16}$
End of cone to inside of grease cap	M. in.	$1\frac{1}{64}$	$1\frac{3}{32}$	$1\frac{5}{32}$	$1\frac{15}{64}$	$1\frac{15}{32}$	$1\frac{5}{8}$	$1\frac{3}{8}$
Undercut width between flanges	N. in.	$1\frac{11}{32}$	$1\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{1}{8}$
Thickness of flange	O. in.	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{2}$
Inside edge of flange to edge of taper	P. in.	$\frac{27}{32}$	$\frac{31}{32}$	1	1	$1\frac{3}{16}$	$1\frac{3}{8}$	$1\frac{1}{2}$
Inside flange over end of housing	Q. in.	$1\frac{11}{64}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{49}{64}$	$1\frac{29}{32}$	$2\frac{1}{4}$	$2\frac{1}{2}$
Width between flanges	R. in.	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	2
Overall length	T. in.	$4\frac{3}{4}$	$5\frac{3}{8}$	$5\frac{3}{4}$	$6\frac{3}{8}$	$7\frac{1}{4}$	$8\frac{1}{8}$	$8\frac{7}{8}$

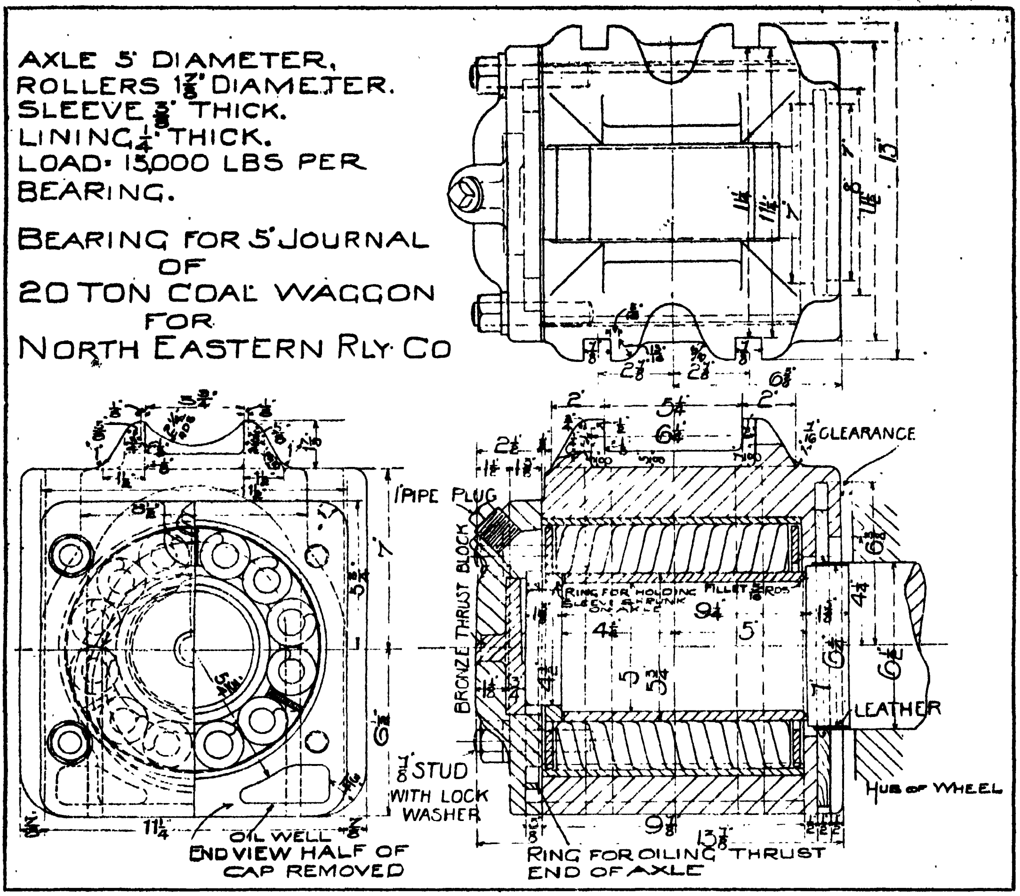
Ball-bearing Hubs. A good example of a ball bearing which takes both end pressure and journal pressure is shown in **148**. It is known as the Hoffmann patent *ball-bearing hub*, and is specially designed for motor-cars and vehicle wheels of all kinds. There are four rows of balls in each hub: the two outer rows take the journal load whilst the two inner rows take end thrust in either direction. The load is taken in each case at right angles to the axis of rotation of the ball, and a perfect rolling action is attained with a consequent minimum of friction. The cone piece is of hardened steel ground out internally to a taper which fits the axle and is held on by a nut and pin in the usual manner. When this nut is removed, the wheel, with the bearing complete, can be taken off the axle. The removal of the wheel with bearing does not interfere in any way with the adjustment of the ball bearings. When it is required to dismantle the bearing, it is done easily by unscrewing the disc nut W at the inner end of the hub, and withdrawing the bearing from that end. The balls are held in retaining cages and do not fall out when the bearing is taken to pieces. Leather washers are fitted to the disc nut in order to exclude dust. A table is given on this page showing the leading dimensions of the heavy type. They are also made in medium and light types.



148. BALL-BEARING HUB

The use of ball bearings as a means of reducing friction between moving parts has wide applications apart from the examples given, but the principles of design and construction do not materially alter.

Roller Bearings. Another anti-friction appliance is the roller bearing, the underlying principle of which is identical with the ball bearing—that is, the substitution of rolling friction for sliding friction. Bearings are made having solid rollers interposed between the shaft and its seating; such bearings when properly designed are a great improvement on plain bearings having sliding friction, but they are not perfect. To obtain the best efficiency and the longest life out of a roller bearing the rollers must be flexible, so as to present even bearing surface along their entire length. The irregularities incidental to the running of shafting and axles prevent the uniform distribution of load over the full length of the bearing, resulting in unequal wear and distortion of the rollers



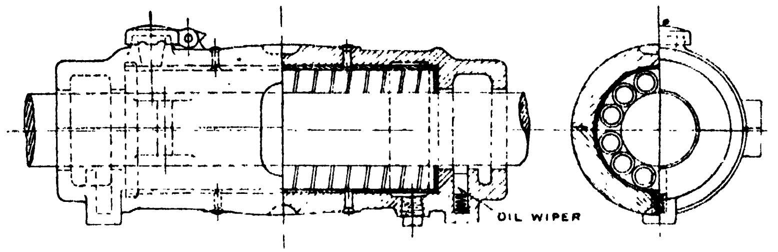
149. WAGGON ROLLER BEARING (Hyatt Roller Bearing Co., Ltd.)

when they are made solid, and consequently rigid. There are several methods of making rollers flexible, one of the best of which is adopted in the Hyatt *flexible roller*. This roller is made from a strip of steel wound into a coil or spring of uniform diameter; it is applicable to all speeds and loads, and can be made of thin material for light loads and high speeds, and of thicker material for heavy loads and slow speeds. The roller acts as an oil reservoir and the spiral grooves as oil carriers. If dirt or other foreign matter get into the bearing it is squeezed into the inside of the roller away from the bearing surfaces.

Eccentric Bearing. Fig. **147** shows an application of the Hyatt flexible roller. It is a drawing of the eccentric bearing of a cotton gin. The bearing is not concentric with the shaft, but the centres are $\frac{3}{4}$ in. apart, which gives a [illegible] throw of $1\frac{1}{2}$ in. to the socket A. This [illegible] is virtually a cam action and is carried o[illegible] high speed of 1,000 revolutions per minute. [illegible] eccentric B has a split steel sleeve fitted to it, [illegible] ground to give a true and hard bearing su[illegible] for the rollers. A similar sleeve or lining is fitted inside the strap C. The rollers lie between the sleeves and are kept in place by a retaining cage, which holds them in such a way as not to restrict their operation but simply to prevent them from getting too far out of line. The split sleeves are shown in detail, and they are kept from turning by pins as indicated in the general views. The strap C is in halves to facilitate removal, and it has bronze end-plates fitted. The bearing is kept flooded with oil.

Waggon Bearing. A unique yet entirely successful application of the Hyatt roller is given in **149**, which is a copy of a working drawing. It represents a waggon axle-box as made for the North Eastern Railway Company. The journal is 5 in. diameter and $9\frac{1}{4}$ in. long; the end of the axle is reduced in diameter and a steel ring is shrunk on in order to keep the sleeve in place. The outer and inner sleeves are split and ground true as in the previous example; the rollers are kept in a retaining age. A bronze thrust block is fitted in the end cover of the box, and also an oiling ring to ensure the lubrication of the thrust block. The external arrangement of the box is normal; there is the usual dust-guard at the inner end and the usual formation of spring

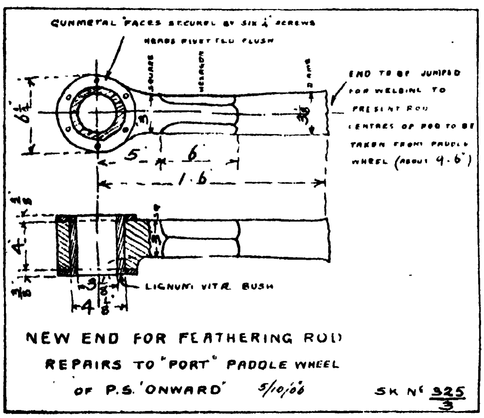
seat on the top. The box has grooves for double horn plates as shown. This bearing after being in use for a twelvemonth is still in perfect condition. This class of bearing is widely used in a lighter form for small cars and mine trucks, and very frequently in such cases the wheels are loose on the axles and contain the roller bearing in their bosses.



150. SWIVEL ROLLER BEARING

Swivel Bearing. Great saving in power is effected when roller bearings are applied to line shafting. Fig. **150** illustrates the construction of one fitted to such a bearing as is shown in **61** on page 3265. The construction is generally as the preceding examples, but the inner sleeve is omitted. Small metal wipers are fitted at each end to prevent oil from creeping along the shaft, and so getting outside of the bearing. Such a bearing is suitable for high speed shafting. The scope of the Hyatt flexible roller is much wider than the examples we give. In motor-car work alone it is used very extensively.

Sketches. Freehand sketches are made for simple details in order to avoid the time and labour of making scale drawings. The sketch should show proportionately the different sizes



151. DETAIL SKETCH

of the article depicted, but it need not be made to scale. Fig. **151** shows a sketch made for a repair job. Considerable art and practice is required to make an intelligent sketch of this nature. It is necessary to give all the information required for the complete manufacture of the article. Many cases of repair are most urgent, and no time can be spared for a second visit to the scene of the breakdown if all particulars be not taken at first. In the case illustrated [**151**] the "Onward" arrives in harbour with her port paddle wheel damaged, and it is highly important that she should leave with the next tide. Sketches accordingly are made from measurement of the broken parts, and new ones are manufactured therefrom in the shortest possible time. Insufficient or inaccurate information on the sketch is a most serious matter.

Duplicating Sketches. Sketches are also made to supplement working drawings when the latter are to be used a second time in the shops but are not strictly correct in some detail. For example, a second machine may be required to be made from a certain set of drawings, and improvements or modifications are desirable; such alterations may not warrant the making of a fresh set of drawings yet the workmen must have definite information to work to, and a record must be kept of both machines. A convenient procedure is to make sketches of the modifications required, and to attach such sketches to the drawing. The office record is obtained by the simple process of making the sketch with ordinary copying ink, and press copying into a book just as one would copy a letter. The reference on the bottom right-hand corner of **151** indicates that the sketch is copied on page 325 of sketch-book No. 3.

Value of Sectional Paper. Sectional paper, or *squared paper*, as it is sometimes termed, is of great assistance in making sketches to scale; it can be obtained in various qualities and rulings. A number of vertical and horizontal intersecting lines are printed faintly upon the paper, the effect of which is to cover it with a quantity of small squares drawn to some definite scale. By the use of this paper fairly elaborate sketches may be made to scale without the use of instruments. Such paper is useful in many ways, one of which is the plotting of lines and curves to show the fluctuation of factors or values; the results of experiments, and tests may be seen at a glance when properly laid down on squared paper in the same manner as we see the variations of a recording barometer.

Another use for sectional paper is the construction of calculating charts; these are used to facilitate calculations by eliminating tedious arithmetic, and they are quite as useful to the draughtsman as is an ordinary slide rule. The strength of gear wheels, belts, columns, etc. can be plotted on a chart in such a way that any two factors being given, the third may be read directly from the chart without calculation.

Continued

Group 21
MATHEMATICS
30
GEOMETRY
Continued from page 4308

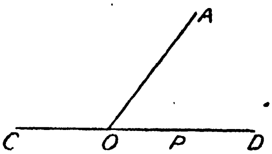
TRIANGLES

Classification of Triangles with respect to their Sides and to their Angles. Equality of Two Triangles. Isosceles Triangles

By HERBERT J. ALLPORT, M.A.

Proposition 2. Theorem

If two adjacent angles be supplementary, the exterior arms of the angles are in the same straight line.



Let the adjacent angles COA, DOA, be supplementary.

It is required to prove that CO and DO are in the same straight line.

Proof. If CO and OD are not in the same straight line, produce CO beyond O to any point P. Then

$\angle$s COA, AOP are supplementary (*Prop.* 1). But

$\angle$s COA, AOD are supplementary (Hyp.).

$\therefore \angle AOP = \angle AOD$.

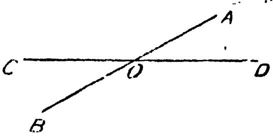
$\therefore$ the line OP must fall along the line OD.

But OP is in the same straight line with CO.

$\therefore$ OD must also be in the same straight line with CO.

Proposition 3. Theorem

If two straight lines intersect, the vertically opposite angles are equal.



Let AB, CD intersect at O.

It is required to prove that

(i.) $\angle DOA = \angle COB$.
(ii.) $\angle COA = \angle DOB$.

Proof.

$\angle$s DOA, COA are supplementary (*Prop.* 1).
$\angle$s COB, COA are supplementary (*Prop.* 1).
$\therefore \angle$s DOA and COB are equal.

In a similar way it can be shown that $\angle$s COA, DOB are equal.

TRIANGLES

1. *Rectilineal figures* are figures which are bounded by *straight* lines.

A *triangle* is bounded by *three* straight lines; a *quadrilateral* by *four*; and a *polygon* by more than four.

A rectilineal figure is
equilateral when it has all its sides equal,
equiangular when it has all its angles equal,
regular when it has all its sides equal and also all its angles equal.

2. A triangle is
equilateral when all three sides are equal,
isosceles when two sides are equal,
scalene when all the sides are unequal,
right-angled when one of its angles is a right angle,
obtuse-angled when one of its angles is obtuse,
acute-angled when *all its angles* are acute.

NOTE 1. Any angular point of a triangle may be looked upon as *the* vertex of the triangle. The side opposite to this angle is then called the *base*. In the case of an isosceles triangle the intersection of the equal sides is generally taken as the vertex.

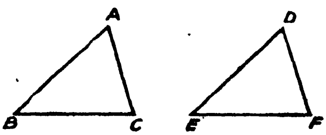
NOTE 2. In a right-angled triangle the side opposite to the right angle is called the *hypotenuse*.

NOTE 3. The three sides and three angles of a triangle form the six *parts* of the triangle.

Two triangles are said to be *equal in all respects*, or *congruent*, when the six parts of the one are equal respectively to the six parts of the other.

Proposition 4. Theorem

If two triangles have two sides of the one equal, respectively, to two sides of the other, and have also the angles contained by these sides equal to one another, then the triangles are equal in all respects.



Let ABC and DEF be two triangles in which

AB = DE
AC = DF
$\angle BAC = \angle EDF$.

It is required to prove that the $\triangle$ABC = $\triangle$DEF in all respects.

Proof. Place the $\triangle$ABC on the $\triangle$DEF so that the point A falls on the point D, and the line AB falls along the line DE. Then, since AB = DE, the point B must fall on the point E.

Also, since the $\angle BAC = \angle EDF$, the directions of their other arms must coincide; so that AC falls along DF. And, because AC = DF, the point C must fall on the point F.

Hence, we have shown that the $\triangle$ABC can be placed on the $\triangle$DEF so that the three angular points of the one coincide with the corresponding angular points of the other.

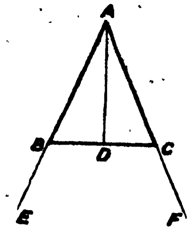
$\therefore$ the $\triangle$ ABC = the $\triangle$ DEF in all respects, *i.e.*

BC = EF
$\angle ABC = \angle DEF$
$\angle ACB = \angle DFE$
$\triangle$s are equal in area.

Proposition 5. Theorem

The angles at the base of an isosceles triangle are equal.

Let ABC be an isosceles $\triangle$, in which AB = AC.



It is required to prove that

$\angle ABC = \angle ACB$.

Proof. Suppose AD is the straight line which bisects the $\angle BAC$, and meets the base at D.

Then, in the Δs BAD, CAD,

BA = CA

AD is common to both Δs,

included $\angle BAD$ = included $\angle CAD$.

Therefore, $\Delta BAD = \Delta CAD$ in all respects [*Prop.* 4].

Therefore, $\angle ABC = \angle ACB$.

Corollary 1. *If the equal sides of an isosceles triangle are produced, the exterior angles so formed are equal.*

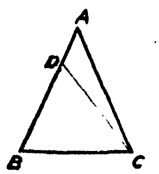
In the figure, $\angle CBE = \angle BCF$.

For they are respectively the supplements of the equal $\angle$s ABC, ACB.

Corollary 2. *If a triangle is equilateral it is also equiangular.*

Proposition 6. Theorem

If two angles of a triangle are equal, the sides which are opposite to these angles are equal.



Let ABC be a Δ, in which

$\angle ABC = \angle ACB$.

It is required to prove that AC = AB.

Proof. If AB is *not* equal to AC, one of them must be the greater. Suppose AB > AC, and from BA cut off BD equal to AC. Join CD.

Then, in the Δs ACB, DBC

AC = DB

BC is common to both Δs

included $\angle ACB$ = included $\angle DBC$.

$\therefore$ $\Delta ACB = \Delta DBC$ in all respects (*Prop.* 4).

Hence the Δs are equal in area, so that the part is equal to the whole; which is impossible.

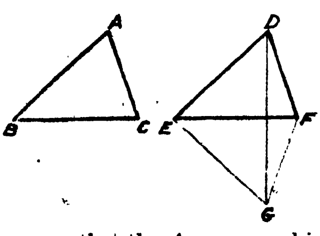
$\therefore$ AB and AC cannot be unequal, so that AB = AC.

NOTE. The above method of proof, which consists in showing that the proposition *cannot be untrue*, is called *Reductio ad Absurdum.*

Corollary. If a triangle is equiangular it is also equilateral.

Proposition 7. Theorem

If the three sides of one triangle are respectively equal to the three sides of another triangle, the triangles are equal in all respects.



Let ABC, DEF be two Δs, in which

AB = DE

AC = DF

BC = EF.

It is required to prove that the Δs are equal in all respects.

Proof. Place the Δ ABC so that the point B falls on the point E, and the side BC falls along EF. Then, since BC = EF, C must fall on F.

Let the Δ ABC fall on the side of EF away from the point D, GEF being the new position of ABC. Join DG.

Then, since DE = GE,

$\therefore$ $\angle EGD = \angle EDG$ [*Prop.* 5];

and since DF = GF,

$\therefore$ $\angle FGD = \angle FDG$ [*Prop.* 5].

$\therefore$ whole $\angle EDF$ = whole $\angle EGF$, *i.e.*, $\angle BAC$.

Hence, in Δs ABC, DEF

AB = DE

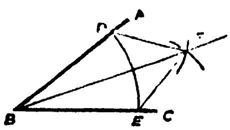
AC = DF

included $\angle BAC$ = included $\angle EDF$.

$\therefore$ $\Delta ABC = \Delta DEF$ in all respects [*Prop.* 4].

Proposition 8. Problem

To bisect a given angle.



Let ABC be the angle to be bisected.

Construction. With centre B, and any radius, describe an arc of a $\odot$ cutting AB, BC, at D and E. With centres D and E, and any radius which is seen to be greater than half the arc DE, describe two arcs cutting at F. Join BF. Then the $\angle ABC$ is bisected by BF.

Proof. Join DF, EF.

In the Δs DFB, EFB,

DF = EF, since they are radii of equal $\odot$s.

FB is common to both Δs.

BD = BE, being radii of the same $\odot$.

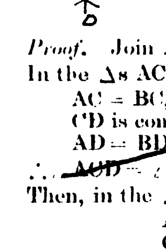
$\therefore$ the Δs are equal in all respects (*Prop.* 7);

so that $\angle DBF = \angle EBF$,

i.e., $\angle ABC$ is bisected.

Proposition 9. Problem

To bisect a given straight line.



Let AB be the line to be bisected.

Construction. With centre A and any radius which is seen to be greater than half the given line, describe an arc. With centre B and the same radius describe an arc cutting the first arc at the points C, D. Join CD, cutting AB at O. Then AB is bisected at O.

Proof. Join AC, AD, BC, BD.

In the Δs ACD, BCD,

AC = BC, being radii of ~~equal~~ $\odot$s. the re

CD is common to ~~both~~ Δs.

AD = BD ~~being~~ radii of equal $\odot$s. the fi

$\therefore$ ~~ACD~~ = $\angle$ BCD (*Prop.* 7).

Then, in the Δs, ACO, BCO

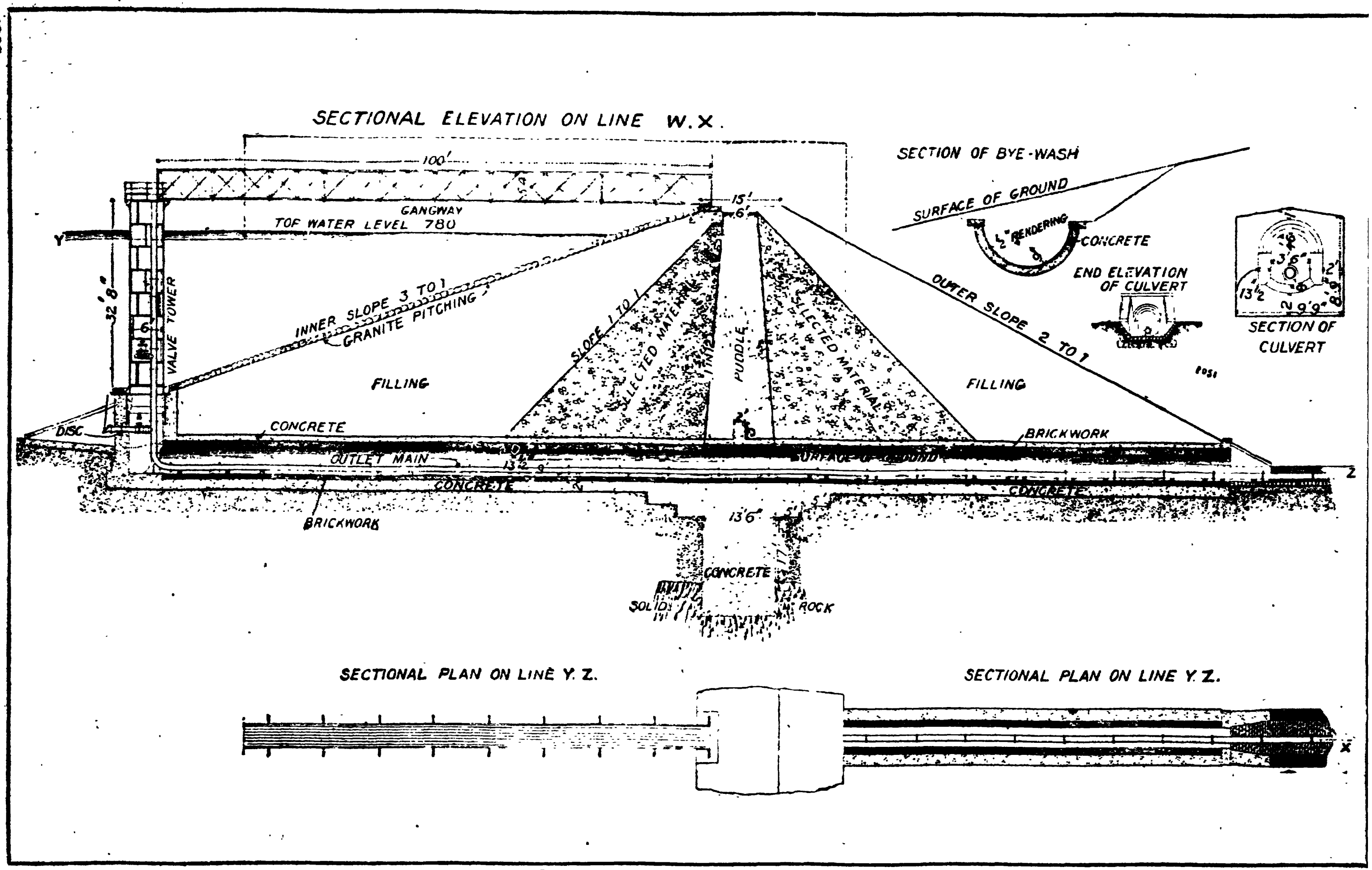
AC = BC,

CO is common.

$\angle ACO = \angle BCO$.

$\therefore$ AO = BO (*Prop.* 4).

Continued



18. EARTHEN DAM FOR IMPOUNDING RESERVOIR

WATER STORAGE & SERVICE

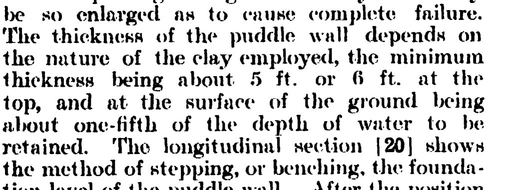
Earthen Dams and their Construction. Profiles. Calculation of Stresses. Service Pipes and Joints

WATER SUPPLY
continued from page 4100

By Professor HENRY ROBINSON

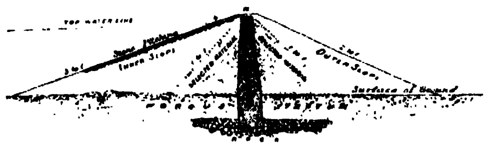
Earthen Dams. The most common form of dam is that composed of earth, with a central puddle wall, as shown in **19** and **20**. This central puddle wall is supported on each side by banks of specially selected material of as clayey a nature as possible, the full width of the bank being made up with whatever other material is obtainable. The width of the bank at the top depends on the height, and also on the weight of the material of which the dam is constructed, but does not, as a rule, exceed 15 ft. or 16 ft., unless a road is required along the top of the bank, in which case the width must be regulated by the requirements of the road.

Puddle Walls. The central puddle wall is the most important part of the work, as on its soundness the water-tightness of the reservoir depends. Even a small leak may rapidly become enlarged by the constant stream of water passing through it, and may eventually be so enlarged as to cause complete failure. The thickness of the puddle wall depends on the nature of the clay employed, the minimum thickness being about 5 ft. or 6 ft. at the top, and at the surface of the ground being about one-fifth of the depth of water to be retained. The longitudinal section [20] shows the method of stepping, or benching, the foundation level of the puddle wall. After the position of the dam has been decided, it is necessary to sink trial holes along the line of the puddle wall, to ascertain the nature of the strata. If it is rock, all fissures must be carefully stopped with good concrete or masonry, and all springs should be led by pipes to the toe of the down stream bank, as if they are not diverted from the bank they will break out at other places and cause trouble. The depth to which the trench should be carried depends on the nature of the stratum, which must be sound and impervious. The trench is sometimes made with vertical sides, and sometimes with battered sides, as shown by dotted lines in **19**, it being considered that any



20. EARTHEN DAM (LONGITUDINAL SECTION)

settlement of the wall tends to consolidate the puddle more effectually than when the sides are vertical. The clay used for the puddle must be carefully prepared and well ground in a pug mill, being conveyed quickly and deposited in position in layers, which should not exceed 6 in. in thickness, each layer being well rammed and trodden down, care being taken to clean thoroughly and rough up the surface of the puddle in the trench before adding the next layer. It is necessary to cover the puddle after the day's work, and to water the surface the next day, in



19. EARTHEN DAM (CROSS SECTION)

very dry weather, in order to prevent cracking.

As the puddle wall is carried up, the supporting banks are brought up with it. The banks should be made in layers of between 6 in. and 9 in. thick, being well rolled, and, in very hot weather, watered. Steam-rollers can be of great assistance in consolidating the bank. The slope of the bank of selected material varies, but is generally about 1 to 1. The slope of the inner bank is as a rule from $2\frac{1}{2}$ or 3 to 1, and is paved with stone pitching, or concrete slabs, in order to resist the action of waves. The outer slope is generally about 2 to 1, and is turfed or sown with grass.

Height of Dam. The height of the top of the dam above the highest water-level depends on the waves, which seldom exceed 4 ft. The height of the waves depends on the "fetch," or length of water surface exposed to wind from any particular direction. A formula known as Stevenson's wave formula may be useful:

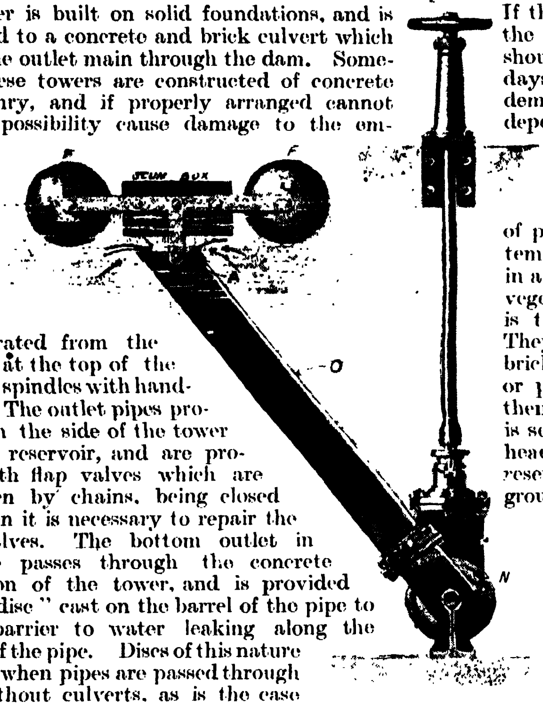
$$H = 1{\cdot}5\sqrt{D} + (2{\cdot}5 - \sqrt[4]{D})$$

where H = height of wave in feet; D = fetch in miles.

Composite Dams. Dams constructed partly of earth and partly of concrete or masonry have been employed in this country, but more frequently in America. The liability of uneven settlement, and consequently of cracking in the concrete, is the chief objection to them. One form of composite dam is that where a concrete, or rubble, wall takes the place of the central puddle wall.

Outlets. The outlet from a large reservoir has to be placed near the bottom, to enable the water to be drawn off in times of drought, or when it is necessary to carry out repairs. As a rule several outlets with valves are provided, so that the water may be drawn off at different levels and the quantity regulated. The number

of outlets depends on the depth of the reservoir. The outlets are operated in such a manner as always to draw the water from about 3 ft. below the surface, thus obtaining it clear and free from floating debris. The lowest outlet is used only in cases of drought or for repairs, as the water is sure to contain a certain amount of sediment. An arrangement of outlets is shown in 18 which is taken from the contract drawing of works carried out by the writer. There are three outlets, each being provided with a sluice valve contained in an iron valve tower standing inside the reservoir at the toe of the bank. The tower is built on solid foundations, and is connected to a concrete and brick culvert which carries the outlet main through the dam. Sometimes these towers are constructed of concrete or masonry, and if properly arranged cannot by any possibility cause damage to the embankment by leakage or settlement. The outlet valves are operated from the platform at the top of the tower by spindles with handwheels. The outlet pipes project from the side of the tower into the reservoir, and are provided with flap valves which are held open by chains, being closed only when it is necessary to repair the sluice valves. The bottom outlet in this case passes through the concrete foundation of the tower, and is provided with a "disc" cast on the barrel of the pipe to form a barrier to water leaking along the outside of the pipe. Discs of this nature are used when pipes are passed through dams without culverts, as is the case with shallow reservoirs of about 20 ft. and less. The outlet pipes of deep reservoirs should be laid in culverts, as shown in 18, of such dimensions that a man can inspect the pipes periodically. The joints of pipes that are laid in culverts can be either spigot and socket, or flanged; but when laid through a bank for shallow reservoirs they must be flanged and jointed, of extra thickness, and provided with fish webs, so that they form, when bolted up, a continuous girder.



21. FLOATING OUTLET

Syphon Outlets. Syphon outlets are employed to draw water from small reservoirs. The syphon-pipe, with air and charging valves on the summit, is carried over the dam to a point lower than the bottom of the reservoir. The depth to which this point must be carried depends on the friction to be overcome in the pipe to enable the required quantity of water to be discharged. Fig. 21 shows a form of outlet known as a *floating outlet* or *floating arm*, often used in storage reservoirs or water tanks. By arranging the floats, F, the water can be drawn off at any required level below the surface, thus preventing floating debris entering the main. The arm, O, is supported by the floats, F, and is pivoted at the point P. When the valve, N, is opened, the water is drawn off at the point A, the floats falling with the water.

Service Reservoirs. Service reservoirs are required in or near a town to maintain the service in case the mains from the source of supply, either storage reservoir or pumping station, reveal any defect, and have to be repaired, or when a fire has to be extinguished. If the town is dependent on one main, the capacity of the service reservoir should be sufficient to ensure two or three days' supply at the rate of the maximum demand. Large cities should never be dependent on a single main. Service reservoirs are generally covered to prevent the possibility of pollution by dust in the air, especially if they be placed in or near centres of population, by birds, leaves, etc. The temperature of the water is kept uniform in a covered reservoir, and the growth of vegetation is prevented. About 14 ft. is the usual depth of water in them. They can be constructed of concrete or brickwork, rendered with cement inside, or puddled with clay outside, to make them watertight. Bituminous sheeting is sometimes used as a lining where the head of water is considerable or when the reservoir has to be built in very bad ground. The covering may consist of light brick or concrete arches supported on piers. On the top of the arches a foot or two of earth is laid. Inlet, outlet, and washout valves are placed in suitable positions. The two first-named should be as far apart as possible, so as to produce circulation. An overflow is provided, and also small ventilators to effect movement and replacement of the air. The cost of an ordinary service reservoir may be taken at about £5 to £6 per thousand gallons.

Stand-pipes. In place of a service reservoir to afford the supply to cisterns at a high level the water is often pumped through a *stand-pipe*, which consists of two vertical pipes connected by a bend at the top, so that a continuous flow of water passes from the pumps through the upcast pipe, over the top, and to the supply pipes on the other side through the downcast. The height of the stand-pipe is governed by the level of the buildings the tops of which have to be reached.

The idea of giving to the cross section of masonry dams a shape of uniform stability and strength is of French origin. A dam has two faces, namely the *inner* and the *outer*, the inner face being frequently called the *back* of the dam.

Calculating Profiles. Sir Guilford L. Molesworth has given formulæ for the calculation of a profile [22] which were published in

the "Proceedings of the Institution of Civil Engineers." They are as follow:

$$y = \sqrt{\frac{0{\cdot}05x^3}{\lambda + (0{\cdot}03x)}}\,; \quad z = \left(\frac{0{\cdot}09x}{\lambda}\right)^4;$$

Width of top of dam $= 0{\cdot}4\,y$, at $\frac{1}{4}$H

Where H = total height of dam in feet,

λ = limit of pressure allowed on the masonry in tons per square foot,

x = depth below the surface of the water in feet.

y = offset in feet to the outer face of the dam from a vertical line = 0·6x as a minimum,

z = offset to the inner face.

He stated that there was almost an exact agreement between his formula and that of M. Bouvier when the limit of pressure allowed was assumed at 5½, 7½, 9 and 11 tons respectively; and he gave the illustration in **23** to show how closely the formulæ were in agreement when treating profiles with the above limits of pressure.

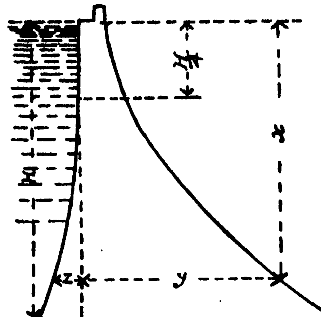
The Molesworth formula is simple, and enables the shape of the cross section to be calculated easily, after which it must be treated graphically to determine the position of lines of resistance.

The conditions of stability for masonry dams are practically two—namely:

1. That the resultant of all forces at any horizontal section must fall within the "middle third" of that section.

2. The stresses in the faces of the dam must not exceed the safe limit.

The first of these conditions is intended to prevent any tension taking place in the masonry.

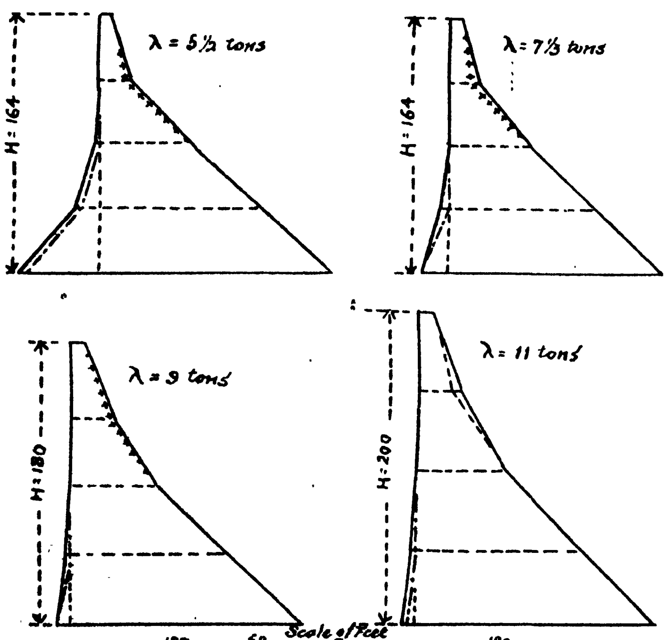


22. MOLESWORTH'S FORMULA

It must be borne in mind, however, that internal forces are set up in large masonry structures—such, for instance, as the difference of temperature—that produce stresses which are in no way due to any external forces which the dam has to resist. It must also be remembered that in all theoretical calculations it is assumed that the dam is a perfectly elastic body, which is not true in practice. Such being the case, ample margin must be allowed to ensure safety, and the stresses that have been allowed on existing structures of a similar kind should be studied as the application of a formula must be governed by the results of practical experience.

Dam Foundations. The first consideration is, of course, the foundation upon which the dam is to be built. It is not advisable to build high dams on earth foundations, on account of the mass of material that would be necessary in order to distribute over a sufficient surface the weight for the earth to support. The best foundations are hard, sound rocks, as these prevent unequal settlement, owing to the varying weight of the wall. The material of the dam must, to a great extent, be governed by the nature of the foundation. After the head of water behind the dam exceeds 100 ft., it is generally thought best to construct it of masonry. It is necessary to avoid continuous courses in the masonry, and great vigilance is necessary in order that no empty spaces may be left between the blocks.

The resistance to crushing of the materials forming a dam is one of the chief points to be considered. The stresses which are set up by the external forces must not exceed the safe limit. As a general rule, this compressive stress should not exceed 150 lb. per square inch, although in cases more has been allowed. M. Bouvier has stated that, with rubble masonry and good hydraulic



23. COMPARISON BETWEEN MOLESWORTH'S FORMULA AND BOUVIER'S METHOD

Molesworth's profile shown thus . . . . ———

Bouvier's „ masonry 135 lb. per cube foot . . . . - - - - -

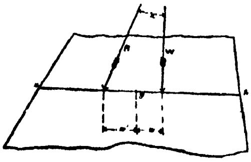
Do. „ „ 150 „ „ . . . . + + + + +

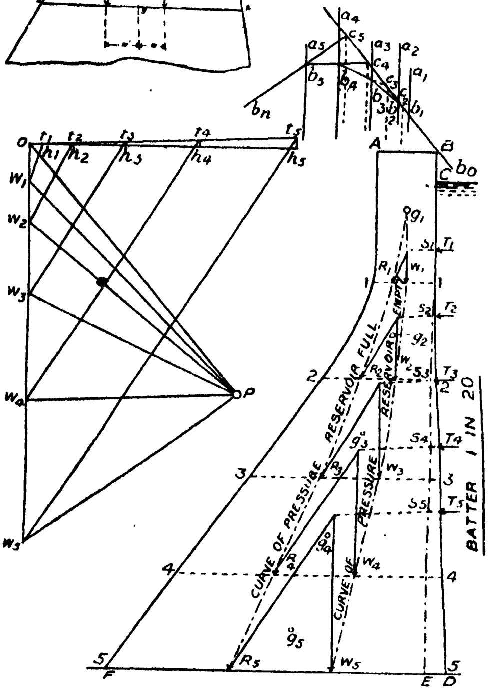
Bouvier's profile is not shown where the divergence from Molesworth's profile is inappreciable

mortar, the compressive stress may be 140 lb. per square inch at the completion of the works, and 200 lb. later on.

The sides of the dam must be built in, and tied to the impervious strata on the sides of the valley across which the dam is made.

Pressure. A profile having been adopted, it becomes necessary to test it to see if there is sufficient masonry to resist the external forces that will act on it, both when the reservoir is full and when it is empty. The curves of pressure in both cases should fall within the middle third of the thickness of the wall. Water





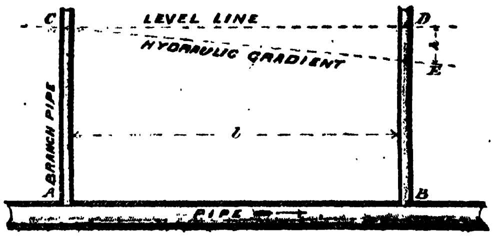
24. COVENTRY'S DIAGRAM

pressure acts normal to the surface of the wall, and therefore, in the case of a curved wall, the pressure is not horizontal, but is inclined downwards. Professor Rankine, in his section for high dams, takes the horizontal pressure, and neglects the vertical component as being on the safe side.

The action of the water tends to overturn the wall on its outer toe. Before this could happen, however, the toe would crush, but if the resultant is within the "middle third," the wall is quite secure from overturning.

In order to test the profile, it is necessary to divide it up into segments, and to test each segment for stability. By this means the curves of pressure for reservoir "full" and "empty" can be drawn, and they must always be within the "middle third" of the section.

In a paper published in the "Proceedings of the Institution of Civil Engineers," Vol. LXXXV.,



25. HYDRAULIC GRADIENT

Mr Coventry gives a formula for calculating the section of a profile, and also a graphical method for testing the stability after the profile is drawn. To determine the stresses in the two faces, the following formulæ were given by him :

Taking any horizontal section $a\ b$ for reservoir empty,

$$s = \frac{W}{l}\left(1 \pm \frac{6u}{l}\right).$$

The plus sign gives the stress at the edge nearest W, and the minus sign gives the stress at the opposite edge.

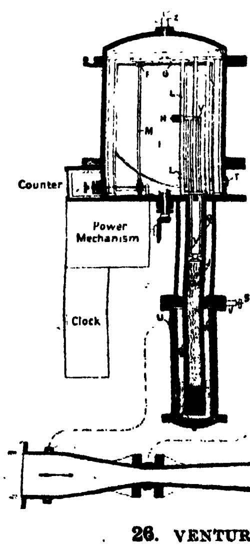
W = weight of the dam above the layer $a\ b$,
l = the length of $a\ b$,
R = the resultant of the water pressure and the weight of the dam.
u = distance of W from the centre of gravity of the section $a\ b$.
u' = distance of R from the centre of gravity of the section $a\ b$.
x = angle the resultant makes with a vertical line.

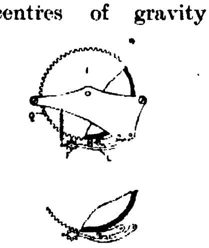
For the full reservoir:

$$s = \frac{R \cos x}{l}\left(1 \pm \frac{6u^1}{l}\right).$$

A useful method for finding these curves is that given by Mr. Coventry, as follows [24]:

The profile must first be divided up into any convenient number of segments as shown by 1-1, 2-2, etc., and their centres of gravity





26. VENTURI METER

found as shown at g_1 g_2, etc. Next construct a force polygon by setting off on a vertical line to scale, the distances ow_1, w_1w_2 etc., equal to the weights of the corresponding sections 1-1, 2-2, etc. On a horizontal line set off to the same scale distances Oh_1, Oh_2, etc., equal to the water thrusts due to the depths for the various sections. Through the points thus found, draw perpendiculars as h_5 t_5, and from the point where the water thrust first becomes normal to the batter draw a line perpendicular to it, and cutting the perpendicular lines at t_2, t_3, etc. Take any point P and draw the lines Pw_1, Pw_2, etc., and also join w_1t_1, w_2t_2. The position of the water thrusts are shown in the figure at s_1, s_2, etc., and s_1 is two-thirds of C1, and s_2 is two-thirds of C2, and so on. The magnitude and direction of these forces is equal to w_1t_1, w_2t_2, etc.

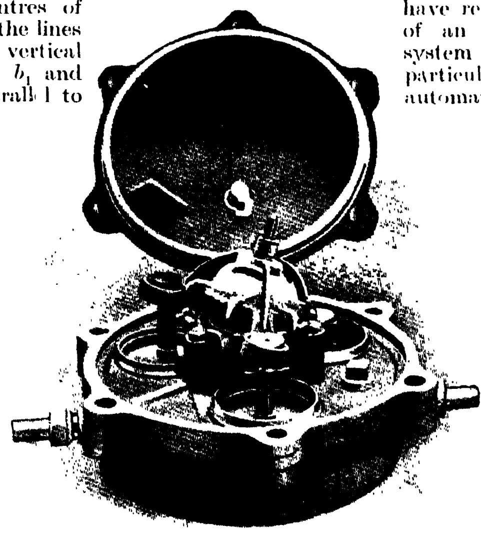
To find the curve of pressure for the empty reservoir, from the centres of gravity g_1, g_2, etc., draw the lines a_1b_1, a_2b_2, etc. In the vertical line a_1 take any point b_1 and through it draw b_0b_1 parallel to PO, and produce it indefinitely. Then draw b_1b_2 parallel to Pw_1, and b_2b_3 parallel to Pw_2, and so on, the last line being parallel to the last radial line on the force polygon. Produce the lines b_2b_3, etc., till they cut the line b_0b_1 produced at c_2, c_3, etc., and through the points drop perpendicular lines to the corresponding sections of the profile. Thus w_2 is equal to the weights of the first two sections, and acts through c_2. The lines joining these points will equal the curve of pressure for reservoir empty. To find the curve of pressure for reservoir full, produce the points T_1, T_2, etc., till they cut the lines w_1, w_2, etc. Through these points draw the resultant forces parallel to w_1t_1, and w_2t_2, etc. Thus, R_1 is parallel to w_1t_1, and cuts the base of the first section. The lines joining these points will give the curve of pressure for reservoir full. From the above it will be seen whether these curves of pressure fall within the middle third of the sections, as they should do. The stresses in the faces of the dam can now be calculated by the formula previously given, as the positions of R and w are now fixed.

Distribution. The sizes of the distributing mains must be large enough to supply the maximum requirements of the community. The sizes of the small branch distributing mains should be 2 in., or 3 in. in diameter. Hydrants for street watering, fire extinction, etc., should be placed at suitable points, and it is desirable to adopt a standard gauge for connecting to them.

In calculating the size of a pipe, the "hydraulic gradient" should be reckoned from the outlet of the reservoir supplying the water to a point about 80 ft. above the highest part of the town, to ensure the delivery of water for fire extinction as well as for ordinary supply to the tops of houses that are, or that may be, built there.

All mains and service pipes should be laid at a sufficient depth in the ground to protect them from the effect of the severest continuous frost. About 2 ft. 6 in. or 3 ft. from the surface to the top of the pipe is the least depth, and the pipes should be tested before being covered. The disregard of this requirement as regards depth has resulted in a few notable failures of the water supply of a district. A very sharp frost for a limited time would not affect the water in the pipes, but a severe frost, lasting for days, does the mischief.

Detection of Waste. Waste-water meters are employed to detect waste, and great savings have resulted. The meter consists of an instrument placed upon a system of water-pipes serving a particular district, and recording automatically and graphically the rate of flow of the water in the pipe. If at a time of night there should be practically no flow, a diagram records the rate of flow, whereby it can be ascertained whether waste is occurring.



27. IMPERIAL POSITIVE WATER-METER

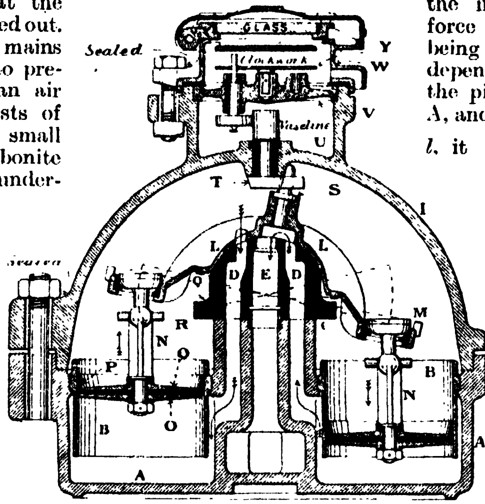
A night examination of service pipes by applying a stethoscope to them enables any flow of water to be detected, when practically there ought to be none. The waste is generally caused by defective fittings, taps left running all night, etc.

Service Pipes. The usual method of distributing water is by cast-iron pipes coated with Angus Smith's bituminous preparation. Pipes more than 3 in. in diameter are generally cast in 9-ft. lengths. Very large pipes are sometimes made in 12-ft. lengths, but small pipes 2 in. or 2½ in. in diameter are generally made 6 ft. long, because a greater length involves risk of breakage in handling and difficulty in keeping the slender core truly central when casting. The lengths are always reckoned from centre to centre of the joints when laid, but the sockets extend 3 in. or 4 in. beyond. The usual form of joint is the spigot and socket caulked with lead. Some hemp or tarred gaskin is rammed into the socket round the spigot end of the adjoining pipe, and molten lead is poured in through a gap in a clay mould, and when set it is rammed home with caulking chisels.

To remove excrescences which form on the inside of pipes, special scraping tools are employed. These are carried on a pair of discs,

or loose pistons, attached to flexible arms. The water is run out of the pipes, and the scraping apparatus is put into a section of pipe, which is closed up, and water is let in at the back of the scraper, driving it forward the length of the flexible arm. When this section has been scraped the tool is removed and another section is attacked. Wash-out valves are placed at low-lying points so that the scraped stuff may be flushed out.

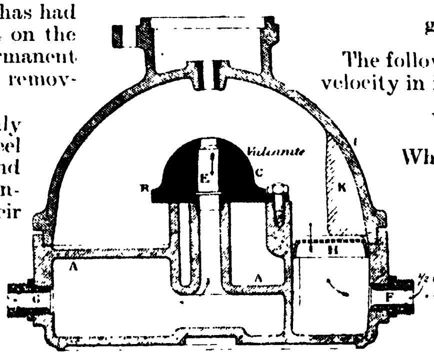
At summits of water mains an air valve is placed to prevent the formation of an air lock. This valve consists of a brass plug, having a small pin hole in it, with an ebonite ball $2\frac{1}{2}$ in. in diameter underneath, held loosely in position by a cradle. When the pipe is full of water under pressure the ball floats up against the pin hole and the pressure of water makes it a tight valve. If air collects, the ball settles down on its cradle and lets the air out, but rises again with the water. A second valve is sometimes used; it has a larger hole to let out the air rapidly when the pipe is being filled after having been emptied for washing out or repairs. As these valves are liable to get out of order, summits should be avoided, especially in pumping mains.



28. SECTION OF IMPERIAL POSITIVE WATER-METER

House Services. Service pipes to houses are generally of lead attached to a gun-metal ferrule screwed into the main. If the water is soft, care must be taken not to use the water for dietetic purposes until it has had time to flow through and act on the lead, thereby producing a permanent oxidation of the surface and removing the danger.

We have so far referred only to cast-iron mains. Mild steel is employed for large mains, and where the pipes have to be conveyed long distances their greater lightness has an advantage. They require to be carefully handled, and if properly coated and protected they have lasted as long as cast iron.



29. IMPERIAL POSITIVE WATER-METER
Transverse section

Hydraulic Gradient. In calculating the sizes of water mains to deliver a required amount of water, consideration has to be given to the friction that has to be overcome by the movement of the water through the pipe. Fig. 25 explains this. h represents the loss of head due to friction caused by the flow of water under pressure. If the water in the pipe were at rest, the horizontal line CD would be the level at which it would stand. If there is a flow from A to B then the level at D will fall below that at C and the line CE is what is termed the ***hydraulic gradient.*** If the velocity is small, h is practically in proportion to the mean velocity v. At high velocities h varies in proportion from $v^{1\cdot 70}$ to v^2, according to the smoothness or roughness of the pipe. The smoother the surface is the lower the index of v will be. The force which moves the water being h, and the amount moved depending both on the size of the pipe, the area of which is A, and on the length of the pipe l, it follows that $\frac{l}{h}$ is the cosecant of the angle of inclination of the "hydraulic gradient," and $\frac{A}{P}$ is what is called the *hydraulic radius*, A being the sectional area of the inside of the pipe, and P the *wetted perimeter* or internal circumference of the pipe. The following formula will enable the discharge through pipes to be calculated:

$$Q = \frac{D^{2+x}}{P\sqrt{S}} \times \left(1 + \frac{T-50}{600}\right)$$

Where Q = the discharge [in c]ubic feet per second,
D = diameter of the pipe in feet,
P = a coefficient of roughness,
T = temperature of the water in degrees Fahrenheit,
S = the cosecant of the angle of inclination of the hydraulic gradient $= \frac{\text{length}}{\text{head}}$.

The following formula will enable the velocity in iron pipes to be calculated:

$$V = \frac{R^x}{C\sqrt[n]{S}} \times \left(1 + \frac{T-50}{K}\right)$$

Where V = mean velocity in feet per second,
R = hydraulic radius in feet,
S = the cosecant of the angle of inclination of the hydraulic gradient $= \frac{\text{length}}{\text{head}}$.
C = a coefficient representing the roughness of the surface of the pipe.
T = temperature of the water in degrees Fahrenheit.

The nature of the surface has a large influence upon h independent of its effect upon the index of v. The temperature also has an influence on the discharge.

The values of "x," "n," and C all depend on

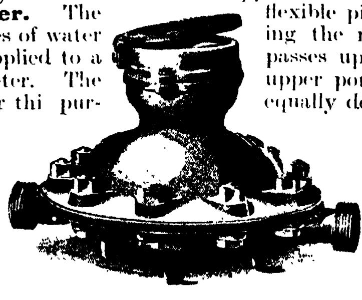
the roughness of the pipe, and from experiments have been found to be as follows:

Factor to which co-efficient relates. Description of surfaces.	Velocity "v"	Roughness C.	Hydraulic Radius "x"	Temperature k.
Cast-iron pipes (new) medium velocity	1·85	0·005347	0·67	600
Cast-iron pipes (new) high velocity ..	2·00	0·006752	0·63	600
Cast-iron pipes (old)	2·00	0·017115	0·66	600
Cast-iron pipes (cleaned).. ..	1·95	0·0074191	0·64	600
Wrought-iron pipes	1·80	0·004787	0·652	600
Riveted sheet iron ..	1·825	0·005674	0·677	600

This subject has been dealt with in great detail in the writer's book on "Hydraulic Power and Hydraulic Machinery."

Measurement of Water. The measurement of large quantities of water either taken from a river or supplied to a town are best effected by meter. The Venturi meter is much used for thi purpose. Fig. **26** shows a Venturi meter from a drawing furnished by the maker. The operation of the meter is due to the fact that when fluid in any pipe passes from a state of rest to one of movement, or from one velocity of flow to a greater velocity, a certain amount of pressure against the shell of the pipe disappears, and the disappearance of pressure, or loss of head, is dependent entirely upon the velocities of flow past the points in the pipe at which pressure is taken. From the illustration it will be seen that the meter is in two parts—the tube and the recorder; there are no movable parts in contact with the flowing liquid. The tube forms part of the ordinary pipe line, differing only for a short distance where it is truncated or throttled, the amount of the throttle being dependent on the maximum and minimum requirements of the place where it is to be employed. The pressure at the upstream end, and at the throat of the meter tube, are transmitted by the small pipes T and U to the recorder, where they are balanced by the displacement of two columns of mercury in the cylindrical tubes, one within the other. The inner mercury column carries a float, JV, the position of which is an indication of the velocity of water flowing through the tube. The position assumed by an idler wheel, H, carried by the float, relative to an intermittently revolving integrating drum, I, determines the duration of contact of gears G and F connecting the drum and the counter, by which the flow for successive intervals is registered. The largest meter-tube that has yet been made is 9 ft. in diameter with a maximum capacity of 200,000,000 gallons in 24 hours.

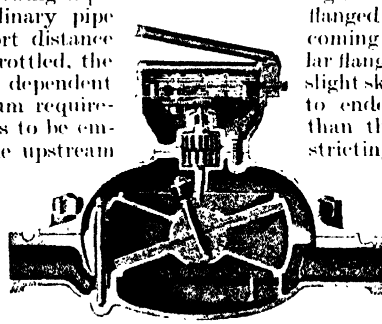
There are numerous meters for measuring small volumes of water, but we shall confine ourselves to two. The Imperial Positive Water Meter is shown by **27**, **28**, and **29**. The lower portion, A, contains three cylinders, B, and the valve-seating, C, with its three ports and passages, D, communicating with the bottom of the cylinders. There is a discharge port and passage, E, and inlet and outlet connections F and G, also a strainer, H; I is the cover, with the rib K for holding down the strainer. An unequal spacing of the bolt-holes prevents the cover from being wrongly fixed to the lower portion. L is the valve with its three arms, in the ends of which are cup-shaped bushes, M, for receiving the spherically-shaped heads of the piston-rods N, and to these are secured the pistons, composed of upper and lower piston plates, O, nuts, and flexible piston caps, P. The water entering the meter, as shown by the arrows, passes up through the strainer into the upper portion of the casing, and presses equally downwards on all the three pistons, and also on the valves.



30. BEE WATER-METER

According to the position of the valve, the lower end of each cylinder in succession is communicating with the outlet passage E, and its piston is therefore forced down by the superior pressure above, thus discharging the contents of the cylinder. At the same time, one or both of the other cylinders is having its piston raised, whereby water is admitted through the passages, and the lower part is filled. Thus each lower end of the three cylinders B is in due course filled and emptied, one or two pistons always supplying the active force, so that there is no dead point.

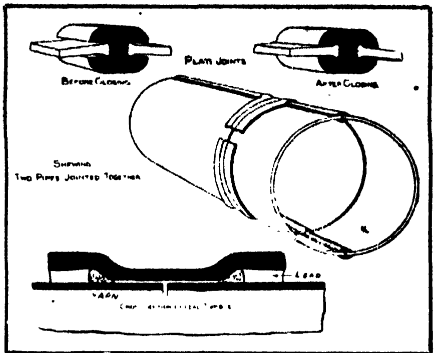
The length of the stroke is regulated by the flanged projection, Q, on the valve L coming into rolling contact with a similar flange, R, on the valve-seating, C. A slight skew of the ports causes the pistons to endeavour to take a longer stroke than they should, the roller paths restricting this tendency. The teeth in the valve and the notches in the valve-seating prevent the valve from turning round on its own axis. The valve-pin, S, engages the crank of the crank spindle, T, which communicates motion to the clockwork in the usual manner. U is the bush in the cover, V the counter-plate supporting the lay-shaft with its worms and wheels. W is the dial-box protecting the clockwork, and Y is the counter.



31. SECTION OF BEE WATER-METER

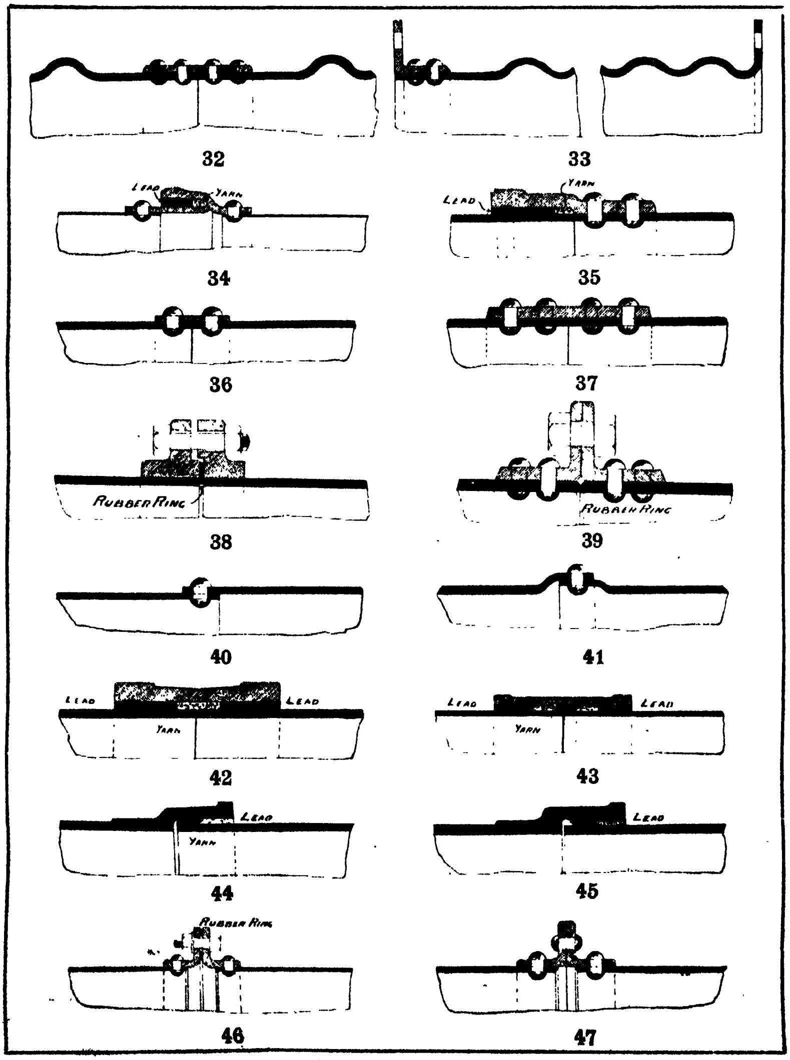
Figs. 30 and **31** show another good example called the Bee Water Meter. This depends on a disc action piston, a chamber of known capacity being successively filled and discharged. The movement of the passing water is directly and positively transmitted to an oscillating piston or disc, which, for each complete motion, or oscillation, shows that the exact contents of the disc chamber, less the bulk of the immersed portion of the piston or disc, have been received.

discharged, and counted, once. For example, let us take a disc chamber with a capacity of 15 cubic in. The portion of the disc immersed is 3 cubic in. Every complete motion of the disc will show that 12 cub. in. of water, or 15 minus 3, has been passed through the chamber. If we divide 1,728 cubic in. (1 cubic ft.) by 12, we find 144 as the number of disc motions required to displace a cubic foot of water, or 6·25 gallons.



48. RIVETLESS STEEL PIPE

Water-pipe Joints. The process of jointing water mains will next be described, and is illustrated in **32** to **47**. Figs. **32** and **33** are forms of expansion joints on large steel water mains. Fig. **34** is a welded spigot and socket, riveted on to a steel main, the joint being completed by yarn and lead. Fig. **35** is a modification of the preceding joint. Figs. **36** and **37** are single and double riveted *butt and strap* joints for steel mains. Figs. **38** and **39** illustrate methods of attaching flanges to large steel mains, the joint being completed by a rubber ring between the flanges; and **40** and **41** show the ordinary forms of single riveted lap joint for steel mains; **42** and **43** are types of double collar joints. Fig. **44** is a spigot and socket pipe joint, commonly used on small mains. Yarn is caulked up to the face of the socket, and molten lead is run into the remaining space in the socket, and well caulked with chisels made for the purpose. Fig. **45** illustrates a turned and bored joint for cast-iron pipes. Where the pressure in the main is small, the lead is sometimes omitted, and is not run in as shown by the illustration. Fig. **46** is a method of joining stamped steel flanges steel mains by riveted on to the barrel of the main, the joint being completed by a rubber ring; **47** is another form of riveted joint used on steel mains.



METAL PIPE JOINTS

A rivetless steel pipe is shown in **48**. The barrel of the pipe is formed by two semi-circular steel sheets jointed by a special metal section, hydraulically compressed into the edges of the sheets, so as to form a rigid and watertight joint.

Water Supply concluded; followed by SEWERAGE

CARPET & COTTON FINISHING

Viewing, Darning, Cropping, Brushing and Calendering Carpets. Starching, Damping and Folding Cotton Cloths. Cutting Fustian

Continued from page 411[illegible]

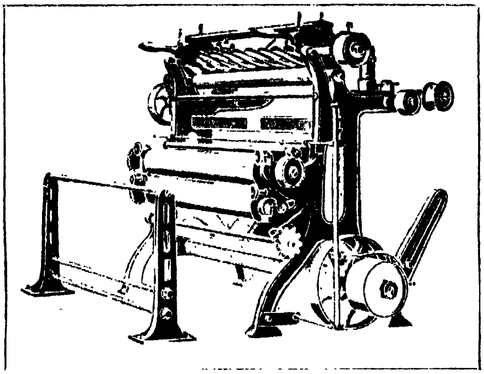
By W. S. MURPHY

THE carpet manufacturer depends very little on the finishing department for the quality of his goods. If the carpet be of good quality and design, and well woven, the finish adds very little to its value. But it must be admitted that the carpet could not pass directly from the loom to the warehouse. Looped-pile and velvet-pile carpets are finished differently, the latter needing the more elaborate finishing.

Viewing. Given an office exactly similar to the burler in the cloth factory, the carpet viewer has a rather difficult task. He must possess a good eye for colour, a knowledge of design, and a practical acquaintance with weaving. Loops or threads may slip, or threads become misplaced without the weaver's knowledge, and as the heavy fabric is unreeled before him, the viewer must spot any and every defect, for upon him at last rests the reputation of the factory. He marks what defects there may be, and sends the carpet on to the darners.

Darning. The work of the darner is to repair the defects of the carpet in such a way that expert scrutiny will not detect the mend. With such a bulky fabric to work upon, the task seems easy, at first sight; but, in reality, imitation of the work of the loom with a needle and thread requires considerable skill. As the darning is purely practical, however, we can do no more than note the theory on which it is based.

Cropping. Axminster, Patent Axminster, Wilton, and Velvet-pile Tapestry carpets have this in common, that they are cropped, or shorn. Up till twenty years ago most carpet manufacturers would have nothing to do with the cropping machine, and at the present day much of the cropping is done by hand; but the machine has been introduced, and steadily makes its way. It is in the velvet-pile tapestry factory that the spiral roller cropping machine has been most largely used. This machine [199] is little more than a large model of the common cloth-cropping machine. The bed is set straight, so as to present a firm surface to the knife, and it crops the surface something in the same way as a lawn-mower crops the grass. The results certainly show well, though the objection of conservative manufacturers that it lessens the wearing life of the carpet may have some truth in it.



199. CARPET-CROPPING MACHINE
(W. Whiteley & Son, Lockwood)

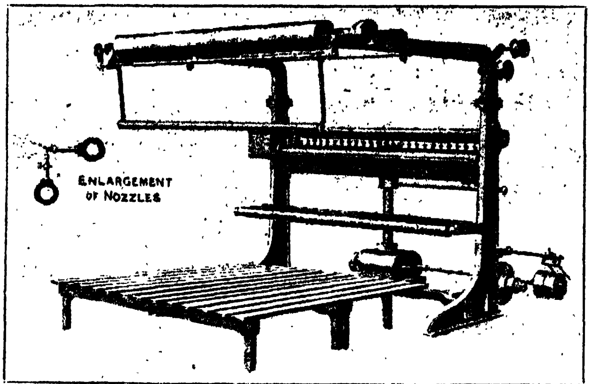
Brushing and Calendering. Carpets are heavy fabrics, and naturally gather a good deal of fluff and stray fibres within them while being woven. Removal of these matters from a Brussels, a Wilton, or an Axminster is a somewhat arduous task; but it is done, and by the simple expedient of brushing rigorously. Brushing machines are variously constructed; but in all we have the combination of fan and brush cylinder such an operation would obviously require. By the fans the dust and fluff are blown into an enclosed receptacle, while the brushes do their work upon the surface of the carpet as it winds round and round. Probably the carpets never experience usage so rough as in this operation. It is amazing what amount of stuff we can take out of a single length of carpet.

When sufficiently cleaned, the carpets are passed through the calender rollers. These are sets of broad rollers hung in a frame, the one above the other, so as to exercise a forcible yet regular pressure on the carpets passed between them.

Sewing and Binding. There is little of technical interest in this department, the work being done chiefly by sewing machines. Carpets woven in strips are carefully joined, and carpet squares are bound with appropriate braidings. It was said of a very clever but unsuccessful manager of a carpet factory that he lost in the ware-rooms what he made in the factory. This is a fact rather more common than is generally supposed. No detail of the industry is too small for the attention of the wise manager.

After the carpets have been sewn and bound, they are again inspected. Any defects apparent are noted and repaired. Then the goods are delivered over to the packers.

Finishing Cotton Fabrics. The number of different cotton fabrics which are finished in the factory is very large. Some plain calicoes are simply passed by the shortest route possible from the loom to the warehouse; cloths that sell at 1¼d. per yard would hardly pay for much finishing. Others, of the same quality, are washed, starched, or



200. DAMPING MACHINE (W. Whiteley & Son, Lockwood)

loaded, calendered, and folded. Fancy fabrics, such as zephyrs, spiders, checks, spots, and check stripes, each comprehending myriads of patterns, are mostly finished in the very simplest style. Fustians, velveteens and moleskins, on the other hand, are elaborately finished both in the factory and elsewhere. Upon the cloths which are bleached, printed, or dyed, we shall not at present touch.

When the cloth, be it plain or fancy, comes off the loom, it is passed into the hands of the viewer, or burler. Over a roller, hung on brackets fixed either in the ceiling of the room or high up on a wall facing the light, the cloth is drawn down by the viewer, who snips off knots and flying threads, and marks faults for repair.

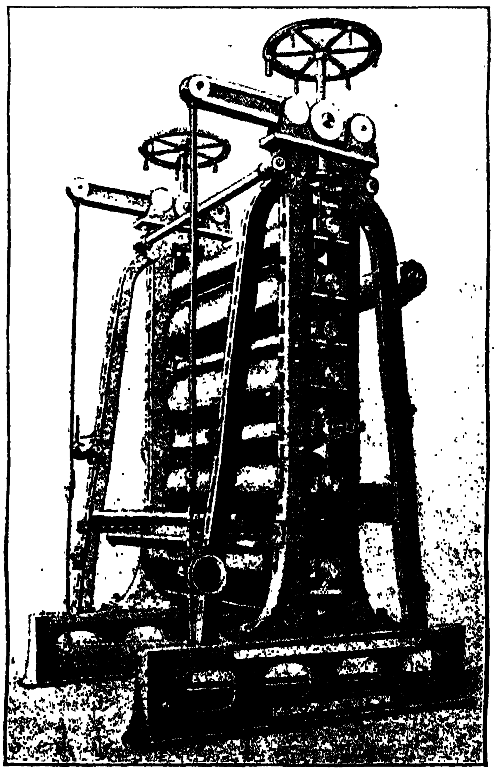
Darning. This work may be very delicate or it may be very simple. To mend a break in fancy cloths woven in figure is a different thing from putting a few threads of plain weft and warp in a common calico or twill. It is purely a matter of practice, however, and is learned in the factory.

Starching. The composition used in starching depends very much on the purpose intended and the fabric to which it is applied. If loading be intended, a mixture of china clay, cereal starch, wax, and some fatty or soapy matters may be used. Care must be taken that the composition has within it preservative elements, and is able to withstand changes of temperature and damp, or else mildew is certain to set in and ruin the cloth. Most export houses have special mixtures of their own. If only the stiffening of the cotton be aimed at, a fine wheaten starch is the best for light goods, and sago, rice, or farina may be used for heavy cloths.

Method. The starching vat is simply one of the many dressing machines. From the cloth beam slung at the end of the machine the cloth is guided down into the starch trough, under a cloth-clad roller revolving in the liquid, up between the clearing rollers, and over the wide, steam-heated drying cylinders.

Starching Fancy Cloths. In dressing faced cloths the starch can be applied only to the back. A simple device effects this very well. Above the roller in the starch vat another roller is placed which receives from the roller below a coating of liquid. This starching roller runs in the direction opposite to the course of the cloth through the machine, and thus presses a coating of starch on the under side of the fabric. Between the clearing rollers and the drying cylinders a number of open reels are placed to harden the starch and keep the drying cylinders clean.

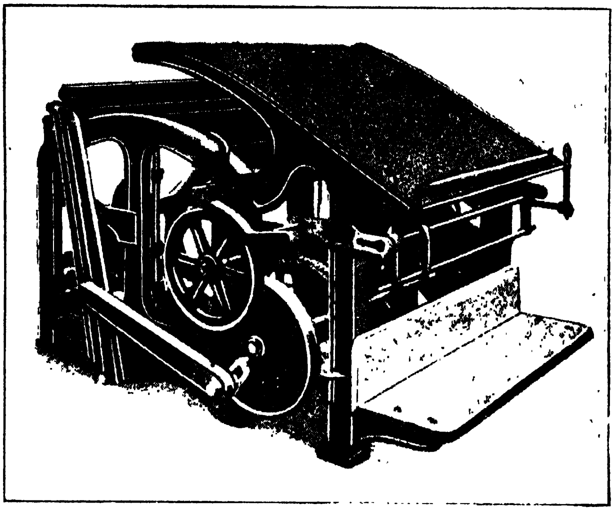
Damping. Dried cloths, whether starched or scoured, are stiff, and do not yield readily to the treatment of the calenders or presses. Most cloths are therefore subjected to damping. Two methods of damping are practised; or, rather, we should say that two kinds of machines are used. On both machines the cloths are run across a space from one beam to another; but it is in the damping apparatus which operates in the intervening space that the differences occur. The older damping machine is a small water tank, with a lid in which a long slit is cut. Within the tank a long-haired brush revolves, sending through the opening in the lid a continuous spray of water on to the passing cloth. The other damper [200] is a spray injector, from the nozzle of which the water is finely distributed. By a curious turn in mechanical development, the newer apparatus is being closely rivalled by an improved model of the older



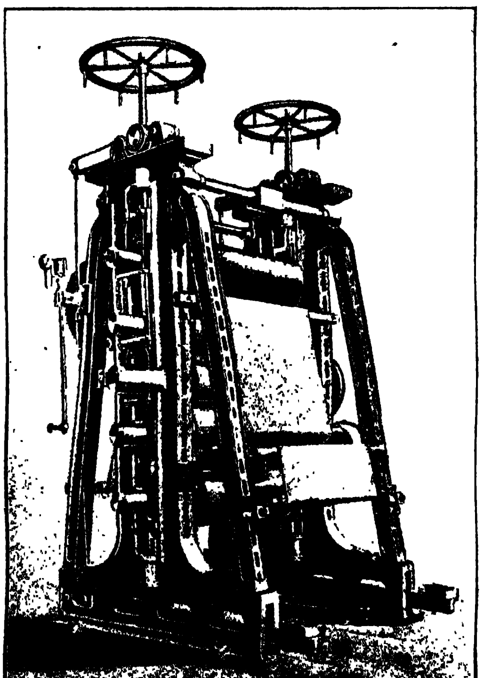
201. CALENDER (W. Whiteley & Son, Lockwood)

machine. By a ball-tap feed the water in the brush-trough is regulated, and the volume of spray is governed by screws on the lid, which enlarge or narrow the opening as required.

Calendering. No textile factory can afford to do without a calendering machine. Many factories employ a large number of various sizes. The chief object of calendering is to produce a smooth and lustrous surface on the cloth. A calender [**201**] consists of a series of rollers and cylinders, placed alternately one above the other in a strong frame. Calenders may have three, four, five, or six "bowls," as the rollers and cylinders are named. The cylinders are generally iron, and always hollow; the rollers are solid, composed of papier mâché pressed to a very dense consistency. The six-bowl calender is representative of the whole class of such machines. Hand screws on the heads of the standards bring the required degree of pressure on the bowls. Beside the screws are two levers which put the drive on to all the rollers. A gearing is set midway up the machine by which only the three bottom bowls may be driven. When a stretching action is desired the top rollers are given a higher speed than the lower section. The heating of the hollow cylinders is accomplished either by steam or by the introduction of red-hot irons. The cloth is wound on to the roller at the foot of the calender, or the web already wound is slung in the same place, and then passes on to the first cylinder, thence round the roller and up through the whole machine, to be delivered at the other side. It is all very simple; but the effects on the cloth are very wonderful.



202. FOLDING MACHINE (Atherton Bros., Preston)



203. MANGLE (W. Whiteley & Son, Lockwood)

Folding. Mechanical folders have developed very slowly, the inventors seeming to err on the side of elaboration. But we have now some good and expeditious folders. One of the best is composed of a curved, movable table, over which a folding arm works to and fro [**202**]. The cloth is given out from the beam, and the folder carries it along to the end of the table, where it is clipped, or held; as the arm comes back it makes another fold. This machine is also a cloth measurer, the number of yards being indicated on the dial attached to the folder.

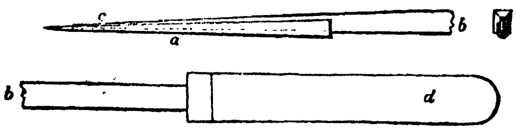
Hand folders, or lappers, are still needed in many factories, and they are very expert workers. The lapper's tool is a long rod named the *broach stick*. With this he both measures out and smooths down the cloth, fold by fold.

Finishing Fustians. The class of cloths named *fustians* includes velveteens, corduroys, cantoons, and moleskins. These are finished by themselves in special ways by experts trained to nothing else. Most important are the velveteens, and to them we shall give special attention.

Velveteens. When weaving velveteen we send the weft threads floating over seven threads of warp. Under a magnifying glass these floating threads are seen to have taken the form of loops, lying in regular rows down the whole length of the web. It is obvious that if those little loops can be halved and the severed ends made to stand up straight, a shallow velvet pile will be made. This is precisely the aim of the velveteen cutter. When the cloth has been taken from the loom, it is stiffened with

a kind of gluey paste or dressing. In that condition it is taken to the cutting-room.

Cutting Frames. After being dressed. the cloth is wound on a roller fitted with a ratchet wheel. This roller is slung on one end of a frame at the other end of which is a similar roller. The frames vary in length from 2 ft. to 10 ft., the short ones being operated by women and the longer ones by men. The cloth is drawn across the frame and fixed on the end roller; then it is tightened and the rollers fixed by the ratchets. In this condition it is ready for the cutter.

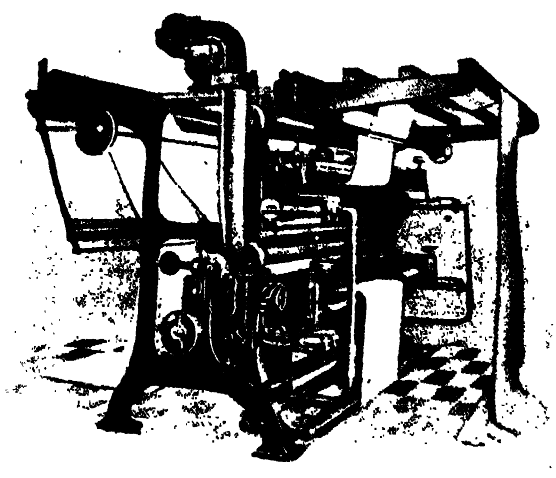


204. KNIFE FOR CUTTING VELVETEEN

Cutting Knife. The chief tool of the cutter is a knife of peculiar form [204]. It is a blade, *b*, 2 ft. long, $\frac{3}{8}$ in. square, tapering to a thin point, and set in a strong wooden handle, *d*, thick enough to fill the palm when gripped firmly. Over the point of the blade is fitted an iron cover shaped like a ploughshare, called the *guide*, *a*, which at once keeps the point, *c*, from dipping into the body of the cloth and lifts up the threads [205] to be cut.


205. VELVETEEN CUT AND UNCUT

Hand Cutting. Before beginning to cut, the cutter lightly brushes the length of the "race" with a piece of card, to loosen the stiffening. Gripping the knife in the right hand, like a fencing foil, and balancing her body on the right foot, the cutter, having gently insinuated the guide under the first few threads, drives the knife smartly forward in a straight and level line along the surface of the cloth. This is the action for the short-frame and plain velveteen. Longer frames and varied patterns like cords and figures, involve movements so complex and varied as to evade description. In a fine piece of velveteen 27 in. wide there are about 500 races; the cutter must therefore perform the action described 500 times to cut a length of two yards. It is slow and arduous work.


206. SINGEING MACHINE (Mather & Platt, Ltd., Manchester)

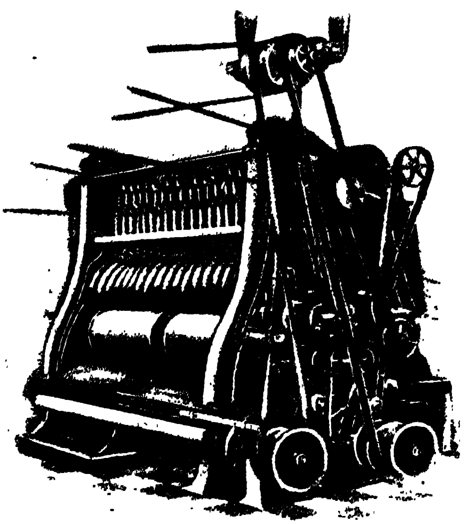
Machine Cutting. Fustian cutting by hand is costly, and a machine which could do the work as well, and more quickly, would be a great boon to the trade. The fact that hand cutting is largely practised is proof that no satisfactory machine has yet been invented. There are many machines, however. As early as 1834, two Salford men, William Wells and George Scholefield, took out a patent for a cutting machine which won approval from many competent judges; but something was wanting, and the machine failed to supersede the hand workers. The problems are very delicate and difficult. After the knife has been made a tool of a machine, and the cloth is smoothly fixed, difficulties still remain. The knife and the cloth vibrate under the cutting, and the sensitive nerves of the living cutter respond to the motions. When the knife slips into the cloth, the cutter feels it at once and stops. Here is a double problem for the inventor. In some degree, a solution has been accomplished by the inventor of the machine now used by many velveteen manufacturers. On a frame 14 yards long, with rollers geared so as to remain fixed at any given point, and movable either forward or backward, the cloth is placed. Midway between the two rollers we find the cutting apparatus. The knife has on its guide, but instead of the long blade and handle the short blade is fixed in a steel plate across the bed of the machine, which responds to the vibrations of knife and cloth. The second half of the problem is not so simply solved, though some success has been attained. By a pneumatic piston and a flexible hinge, the knife is rendered sensitive to the lightest obstruction. A knot or a puncture at once throws it out of action. In addition, the knife is watched and set to work by the attendant, who is seated at the point of cutting. The knife cuts at the rate of 2,000 ft. a minute, and at the end of the race the cloth is wound back to the starting point, until the whole breadth has been cut.

Enders and Menders. Small punctures and other faults must be expected to occur, both in the hand cutting and on the machine. When the cutters are done with it, the cloth is handed over to the darners, who are named *enders or menders* in the trade. They carefully inspect the web, and fill up the faults with darns imitative of the rest of the fabric.

Outside Operations. After being darned, the velveteens and corduroys go out of the textile factory into the hands of the bleachers, dressers, dyers, and calenderers. Our duty at

this stage, therefore, is simply to inquire into what work we expect from those operators. First, the cloth must be freed from all the sizing and stiffening which have served us in the weaving-shed and the cutting-room. The cloths are soaked, washed, and dried. Secondly, the pile is brushed up on brushing machines. Thirdly, the pile is cropped level on cutting machines with spiral knives. Fourthly, the surface fluff is removed by singeing, either on the hot copper roller or through the gas flame [206]. Fifthly, the cloth is bleached by the common bleaching process. Sixthly, the dyer puts on the colour. Seventhly, the pile is waxed by being passed through between rollers of solid beeswax. Eighthly, the brushing machine again comes into use, to raise the pile. Ninthly, the pile is gently "pegged" on a machine that strokes the cloth with a strip of hard wood. A finishing pegging is given the cloth by hand on tables of stone. The lappers or folders last make up the cloth for the warehouse.

Finishing Linens. Most of our linen fabrics pass through the bleaching process, which is fully explained in the Dyeing section of this course. In several other respects, the finishing operations on linen resemble closely those of the cotton factory. The finishing department of the linen factory, however, has some special features.



207. BEETLING MACHINE (Mather & Platt, Ltd., Manchester)

Beetling. Whoever discovered the secret revealed in beetling made a surprising hit. To change the appearance and character of a cloth by merely beating it with a club, is a wonderfully economical performance. Very probably the inventor was a woman. In olden time, the housewife, when the family linen had been washed, took a flat club, named a beetle, and beat the folded linen flat and smooth, stretching out wrinkles and bringing the fibres up closer to each other.

Beetling Machines. The machine-maker has undertaken no great transformation of the domestic beetles; he has simply made them automatic and power-driven. The wooden pillars are set up on end, with projections fixed on the back of each. A roller behind turns on these projections, and lifts them up in rapid succession, letting the ends of the wooden blocks fall by their own weight. The cloth is wound on a wide roller placed below the beetles, and as it turns, the heavy blocks beat upon the fabric, at the rate of 100 blows a minute. Different effects may be simply brought off on the beetling machine. Imitation of watered silk is produced by the disposition of the cloth in layers, so that the threads are variously pressed. Fine moireens are made in this way. Damasks, fine hollands, tablecloths, and table linens, are smoothly finished in the beetling machine, the threads being flattened and closed up, while a fine lustre is created.

Other beetling machines have been brought into use, mostly designed to expedite operations. A rapid machine is that of Mather & Platt [207], the blocks of which are suspended on leather straps attached to semicircular springs, which are worked by a crank from the head of the machine. It delivers about 450 blows a minute.

Mangling. This is another of those finishing operations which, though accepted in many branches of the textile industry, properly belong to the linen trade. The object of mangling is the stretching, smoothing, and lustring of the cloth. Mangling was first mechanically performed by a small waggon heavily loaded with stones running on rollers over a smooth table. This very clumsy appliance has long been discarded. Pressure is obtained by powerful screws, and the to-and-fro motion is accomplished by reciprocating rollers. With the exception of the weight and the reciprocating motion, the mangle [203] is little more than a form of calendering machine. Mangling is variously applied. Sometimes the cloth is taken direct from the beetling machine to the mangle, and in other cases cold calendering precedes the mangling. These are matters of factory practice.

Calendering, viewing, darning, and folding operations in the finishing of linens differ very little from those we have already seen in the other textile factories.

Jute. The factory finishing of jute itself is chiefly calendering. The calendering machines are large and heavy, but of the same structure as the common calenders used for lighter fabrics. Jute, however, is the basis of many floorcloths, oilcloths, and linoleums. The manufacture of these fabrics must be studied separately, and in the course of our examination of the processes of manufacture we shall deal with the whole subject of jute yarn and cloth finishing.

Continued

Continued from page 4148

CYCLOPÆDIA OF SHOPKEEPING

PAWNBROKERS. Legal Restrictions. Possibilities of Pawnbroking. Dangers and Risks of the Trade. Disposal of Forfeited Pledges

PERFUMERS. Selling Perfumes as a Department and as an Independent Business. Finance, Capital, Profits and Side Lines

PAWNBROKERS

Of all careers open to a man on fortune bent there is perhaps none less inviting than that pursued by the pawnbroker. For ages he has been covered with obloquy, regarded as a pariah by society, and made a scapegoat of by those whose business it is to restore property to unfortunate persons whom thieves have despoiled.

Pawnbroking appears to have started as a separate trade about the reign of James II. (1685–1688), and from its very beginning its followers have been subjected to the most virulent attacks. Sermons have been preached, speeches delivered from platforms, and articles published in magazines and newspapers, all having for their text the iniquity of pawnbroking and the imperfections of all connected therewith. This prejudice has grown stronger with age, more inveterate from repetition of the attacks, and has been known to culminate in tirades which, it is not too much to say, exceed the bounds of common decency. The whole trade of pawnbroking has been stigmatised as dishonourable, and the pawnbrokers themselves as little better than criminals.

Present Day Pawnbroking. Whatever may have been the truth in the past—and with that we have here nothing to do—pawnbroking is now carried on in the light of day. Its operations are controlled by statute, while its followers are invariably men esteemed by their customers and neighbours. No other tradesman, except, perhaps, the licensed victualler, is surrounded by law as the pawnbroker. The Act of Parliament regulating the trade actually bristles with penalties for the infringement of any of its sections, almost any one of which may be put in motion upon application to a magistrate. It speaks well, therefore, for the members of the trade that so few charges of any importance have been brought home to them. It is claimed for them, and so far has remained undisputed, that more of almost any profession and business have been convicted of serious crimes than there have been pawnbrokers. Still the bad name has stuck to them as to the proverbial dog.

A Dying Trade. It has been stated upon no less authority than that of Mr. John Burns that pawnbroking is one of four dying trades. From what source the President of the Local Government Board derived his information has not been made known, but a long and intimate acquaintance with the trade leads one to believe that he has a strong foundation for the assertion. The number of pawnbrokers is less in proportion to population than any other trade, and, what is more, the proportion shows less and less with each recurring Inland Revenue Report. During the last five years the increase in the number of pawnbrokers in England and Wales was only 33—namely, from 4,280 to 4,313, an average of less than seven per annum, while the population of England and Wales increases at the rate of 350,000 a year. In Scotland the number of pawnbrokers' licences issued in the same period has gone up from 425 to 453. In Ireland there has been an actual decrease. Ten years ago 382 licences were granted; to-day there are only 317. The reason given by pawnbrokers themselves for this restricted growth of the trade is that existing businesses have not been sufficiently remunerative to encourage fresh enterprises. They are constantly complaining that there are too many in the trade, and that it suffers greatly from the consequent competition, although, as before stated, the number is less in proportion than any other trade in London. In many provincial towns there is no pawnbroker's shop to be found. It is only in large industrial and manufacturing centres that the pawnbroker can make a living.

Profits Permitted. Pawnbroking in Great Britain is conducted under the Pawnbrokers' Act, 1872 (35 and 36 Vict. c. 93). The profit fixed by that Act is at the rate of one halfpenny per florin per month up to the sum of £2, or 25 per cent. per annum; above that amount, one halfpenny per half-crown, reducing the rate to 20 per cent. For sums above £2 the Act permits of special contracts being entered into, where the rates are mutually agreed upon as well as the term of the loan, providing it is not less than three months. Every ticket issued by the pawnbroker contains on the back an abstract of the Act setting forth in a clear and precise manner the profit he is entitled to charge, together with other essential information. Any excess upon these charges brings him directly under the penal clauses of the Act. The trade in Ireland is carried on under special Acts of much older date.

Within a radius of ten miles from the Royal Exchange, London, there are 692 pawnbrokers' shops, the average number of pledges taken in per month at each shop being estimated at 5,000, making an aggregate of 3,460,000, or 41,520,000 pledges per year—about seven to each head of the population. The average value of each pledge is 4s., therefore the amount annually advanced to the poor of London is £8,304,000. In these figures pledges of more than £10 are not taken into account, as they do not come within the provisions of the

Pawnbrokers' Act. Yet a very large proportion of the London pawnbrokers, as well as many in the provinces, do a large business in that way.

Present Conditions. With such a turnover it would be thought that the trade of pawnbroking would be prosperous and flourishing; yet such is far from being the case. The good days of pawnbroking are over; competition is too keen, and too much is therefore lent upon the goods. It is a well understood maxim in the trade that the man who makes the biggest advances does the most business, and though in this way, by doing "large numbers," as it is called, ticket money—for a loan of 10s. or under, one halfpenny, and above that sum one penny—amounts to a considerable item, the loss on the realisation of forfeited pledges may easily lead to disaster. It should be remembered that all pledges above 10s. must be sold by auction; goods pledged for 10s. and under become the absolute property of the pawnbroker unless they are redeemed within a year and seven days.

Forfeited Pledges. Many pawnbrokers dispose of their "lows" in bulk—frequently at a discount off the amounts lent—while others utilise them in their own sale department. The latter process is generally the more remunerative, especially if the articles have been carefully "taken in." These statements may not be in accordance with the popular idea regarding a pawnbroker's profits, but they are strictly accurate, and may be verified by reference to the advertisement columns of their trade journal. Few people realise the difficulty of selling second-hand goods. It has been said that one of the finest tests of a salesman's capabilities is to get him to try to sell a second-hand coat. A brief experience will teach the novice that it is by no means an easy matter in these days when the market is flooded with cheap and shoddy material, with cut, colour, and fashion constantly changing. The difficulty is quadrupled in regard to women's clothing.

Possibilities of Pawnbroking. In spite of its unpopularity and somewhat unsavoury nature, a good living may yet be made out of pawnbroking. It is anything but a "get rich quick" occupation, for it is a fact, though little understood by the public, that the pawnbroker works for less profit than any other class of tradesman. His "profit"—the word made use of in the Act of Parliament regulating the trade—on every two shillings he turns over is but a halfpenny, far less than is made by the butcher, the baker, the grocer, draper, or any other shopkeeper with whom we have daily dealings. As one of their number puts it, the pawnbroker does not get 25 per cent on his turnover, as is popularly imagined, but his profit or interest is calculated at the rate of 25 per cent. *per annum*, which is a very different thing. Most retail traders price their goods so as to secure 25 per cent. profit upon their turnover, so that it follows that if a tradesman has a turnover of £50 per week he makes a gross profit of £12 10s. If a pawnbroker has a turnover of £50 per week he would not get more than a gross profit of £2 10s. to £3, and that would include his charge for tickets as well as interest.

Qualifications of the Pawnbroker. To succeed in the business a man requires knowledge, ceaseless perseverance, and capital. In the metropolis few pawnbrokers employ in their business less than £2,000, many as much as £10,000, some £20,000, and others considerably more than £30,000. In the provinces there are businesses carried on upon a capital of £500, but under such circumstances it must be a hard struggle to find the wherewithal to meet the demands for wages, rent, rates, taxes, fuel, light, licences, insurance, and the numerous small expenses incidental to all retail businesses, to say nothing of household and personal outgoings. The cost of a pawnbroker's licence is £7 10s., and expires on the 31st of July. Those who make advances on gold or silver articles are also required to take out the higher licence to deal in plate—namely, £5 15s.

As may readily be conceived, the difficulties besetting the business of lending upon portable securities are enormous. The ideal pawnbroker should know the value—that is, the selling price of every article under the sun, anything that has any market value whatever. Needless to say, if such a person exists, he is very difficult to find, and he would probably make a better living in another trade. The pawnbroker deals in everything, and has to exercise his judgment as to the character of the thing offered as well as of the offerer. As a rule, he goes upon the assumption that it will be redeemed, and therefore lends as much as he can upon the article with a due regard to the price it will fetch under the hammer, or, in the case of "low" pledges, in his sale shop. Attention to market value—that is, the price at which any article will readily find a purchaser—is the essential for the man behind the pawnbroker's counter. Experience alone will enable him to attain this desirable qualification. A man can scarcely be at the same time an expert upon precious stones, a judge of silks and satins, and fix the value of an overcoat and a pair of boots. Yet this is the pawnbroker's daily task.

Stolen Property. Apart from these difficulties there are others with which the pawnbroker has to contend. He has to avoid taking in pledge property not lawfully acquired, or to which the pawner cannot confer a good title. He must also perpetually be on his guard lest he fall a victim to the wiles of the "duffer." The first is not an easy matter, for the pawnbroker has no more means of distinguishing the thief than has the owner of the stolen property or the policeman who is searching for it. When traced to his keeping, which generally happens through the pawn-ticket issued by the pawnbroker, the latter has, in most instances, to restore the article without compensation. Now and then, by grace of the magistrate, he receives a third or a half of his advance.

"Duffing" the Pawnbroker. "Duffing," or "mosking," is a career pursued throughout the country with considerable success. It consists of purchasing or manufacturing

goods, and pledging them at a profit. Numbers are engaged in it, making their way from shop to shop, and from town to town, until they have succeeded in persuading some unwary pawnbroker to advance them the sum they are prepared to accept. This may be considered a legitimate business, but there are other practices which are not so guileless.

There is no royal road to pawnbroking. It cannot be learned or conducted by rule of thumb, but demands from its followers sheer hard work and close application; neither can it be imparted through the pages of a book. The pawnbroker must keep his nose to the grindstone all day long, and the man who succeeds in making a competence at the business would probably do so far more quickly in any other industry. The remuneration is slow, but it is certain. Pawnbrokers nowadays, outside Scotland and Ireland, at least, carry on a sale trade comprising jewellery, clothing, furniture, etc., and the two businesses materially assist one another. It has been advanced as a reason for pawnbrokers getting on so well in the world that they conduct five or six businesses under one roof.

Assistants. It is impossble to state the average wages paid to assistants. Everything depends upon the nature of the business. As in other trades, the West End houses require far more experience and ability in their employees than do those in the East and Southern districts. Experience gained in the East End of London is of very little use in the West, and experience gained in the West is of no use in the East. Of late years the once general custom of apprenticeship has died out. Boys are required for the warehouse where the pledges are stacked, also to write tickets and to book up the day's transactions. After some probation, a smart lad may be employed at the pledge counter, where his real experience begins. The sale shop is generally distinct from the pawnbroking. "Living in" is the rule, and when speaking of wages has to be taken into account. An average London pawnbroker's establishment would comprise a manager or foreman, second and third hands, one or two warehouse boys, and possibly a porter. Boys living in would get from £6 to £9 for the first year, and the porter £30 to £50. Excluding a limited number of very high-class houses, where exceptional ability is demanded and well remunerated, the average pawnbroker's manager living in would get about £100 a year, the other hands receiving from £30 upwards. A proportionate increase would be given to those not living on the premises. In many houses it is customary to allow a commission on sales. Anyone contemplating entering the trade should reflect that, unless he is a man of considerable means of his own, or has some very substantial friends with unlimited confidence in him, the prospects of quickly rising to the rank of a master are not hopeful.

Books on Pawnbroking. The only books dealing with the subject are legal handbooks, the most up-to-date of which is the "Law of Pawnbroking," by Charles L. Attenborough (1897). The trade organ is "The Pawnbrokers' Gazette and Trade Circular," published weekly. The National Pawnbrokers' Association and various metropolitan and provincial societies exist to protect the interests of their members. There are also a number of flourishing charitable and benevolent institutions in connection with the trade.

PERFUMERS

To-day perfumes are sold largely by chemists, hair-dressers, drapers, and in all the departmental stores. The true perfumer—he who keeps open shop for the retail sale of perfumes and toilet articles alone—is not often to be met with nowadays, not so often perhaps as he might be. For there can be no question but that there are many openings, especially in the larger and better-class cities and towns in the country, for a practical perfumer who knows the business thoroughly, and who is prepared to do it well. Of course, perfumes and toilet adjuncts are more or less luxuries. The neighbourhood selected must therefore be a good one, and the shop, stock, and appurtenances must appeal to the æsthetic in mankind, and especially in womankind.

How to Learn. The business is best learned in a chemist's shop. There the manufacture (or blending) and the sale of perfumes is a regular part of the chemist's business. Moreover, the science of chemistry plays a very important part in the modern art of perfume-making, and the youth who is taught the scientific compounding of compatibles and incompatibles in his daily routine is learning the prime essential of the making of agreeable scents. Of course, an apprenticeship of four years to a regular perfumer, either wholesale, manufacturing, or retail, may serve the purpose quite as well, but it is a noteworthy fact that most of the successful perfumers of the day have been chemists first and perfumers afterwards.

What to Learn. The things to be learned during the novitiate are many and various. First, and most important of all, there must be the "cultivation of the nose," as it might be termed. The successful perfumer has so highly trained a nose that he can detect delicacies of smell that elude the ordinary person. This is a matter of experience and application, but primarily of instinct. The business of the novice is, therefore, to become acquainted with the properties and possibilities of the various crude products with which he is brought into contact, so that he can evolve something pleasing to the senses. He is taught how to blend essential oils of lavender, origanum, sandal, orange, lemon, and what not, in certain proportions with rectified spirit or with perfumed waters in such a way as to produce a perfume. He macerates musk, orris-root, ambergris, and so on, to make bases for recognised perfumes, and he learns how to distil flowers for the preparation of the oils they contain, and how perfumes are prepared from fresh flowers by simple absorption in a fatty medium. He comes to know the value—and the worthlessness—of various synthetics which are often employed in the manufacture of cheap perfumes, and the

kinds of bottles to buy for bottling certain brands, the style of labelling, capping, and tying with ribbon, packing, and so forth, that is necessary to produce a finished product that will sell. Furthermore, and vitally, he acquires inside information into costs and profits, and the advantages of adequate display. Joined to perfumes and part of the family tree, so to speak, are many toilet dainties in which perfume is an essential, and often the essential ingredient. So the youth who has mastered in a kind of way the art of making a perfume has yet to learn the many ways in which it is adapted to the taste of the dainty lady of fashion. He is taught, or ought to be taught, the mysteries of making perfumed sachets, toilet creams, face powders, pomades, lip salves, cold-creams, cosmetics, bath powders, massage lotions, hair dressings, brilliantines, hair restorers, theatrical grease paints, and a host of allied preparations that are intended to make the plain beautiful and to stave off the ravages of Time. The question of toilet soaps itself is a large one.

Ways and Means. An adequate experience having been acquired, the young man (or woman) with a capital of £500 might essay a new business. As before mentioned, the shop selected must be in a good-class neighbourhood if the adventure is to be made on perfumery and its adjuncts alone. It must be done well, or not at all, for the cheap perfume business is not worth the candle. Those who want cheap perfumery can get all they desire in endless variety from the draper, the hairdresser, or the chemist. So a modest shop in a good-class, busy thoroughfare of a good provincial town, or a flourishing metropolitan suburb, should be secured and fitted up well. It will pay to spend at least £200 on good fittings in an eligible neighbourhood. Light oak, mahogany, or other fancy wood, carved or plain, but in good taste should be chosen. The window should be carefully looked to, and fitted so that it will display in the daintiest manner possible the delicate stock that is to tempt the passer-by. Some tastes run to velvet plush draperies of various shades in the window, while others affect plain oak recessed compartments with brass standards for displaying goods, and mirrored backs, sides, tops, and bottoms. The regulation shop with counter and cases has given place of late years to the *salon* style of shop interior. A handsome carpet on the floor, a perfume case of one design here, another of a different style there, a profusion of mirrors, palms, and flowers dotted in odd corners, with handsome cut-glass show perfume bottles, perfumed soaps or toilet specialities insinuated in unexpected places, but not obtruding on the general scheme, dainty curtains, a delicate perfume, and a general air of luxury; such is the modern perfume *salon*.

Buying. The young perfumer would not at first attempt to make and bottle his own perfumes entirely. He would probably have a "bouquet" evolved from his inner consciousness, in which he had hopes of great popularity, and this he would manufacture and put up as a send-off. It would require to have a catchy name, and be original and attractive in style of get up. Nowadays, most wholesale perfumers, manufacturers of toilet soaps, and makers of toilet articles, offer perfumes, soaps, and other goods, packed in a selected style and labelled with the retailer's own name and address. The opening stock need not be large; in fact, it should be as small as possible, keeping in consideration the ephemeral nature of the goods and the danger of soiling labels and caskets. The amount expended in stock would not, therefore, be more than £150. For one must remember that crowded perfume cases are neither artistic nor necessary.

What to Buy. First and foremost, the beginner would select about 10 lb. of assorted perfumes in bulk. These would include the more popular perfumes (in triple extracts for reduction with spirit or otherwise), such as jockey club, essence bouquet, heliotrope, Parma violets, lily of the valley, moss rose, musk, myosotis, new mown hay, stephanotis, sweet pea, wallflower, white rose, ylang-ylang, and so forth, which he would order in ½-lb. or ¼-lb. quantities at a cost of from 9s. to 10s. 6d. per lb. Then he would carefully choose an assortment of bottled perfumes, in 1-oz., 2-oz., 4-oz., up to 8-oz. sizes. One gross of the 1-oz. size would probably cost about £10, half a gross of the 2-oz. size, about £8, three dozen of the 4-oz. size £5, and so on. It must be distinctly understood that no cheap perfumes should be touched, except in rare instances, and great care and thought should be exercised in the selection, which should not require more than £30 to £40 all told. Beside the bottled perfumes, there are also caskets or cabinets containing bottles of assorted styles, the caskets themselves being works of pictorial art and chaste decoration. A sum of £10 should secure a good display of caskets in designs to suit all tastes. Besides these, there are the proprietary brands to be stocked. Another £15 to £20 would have to be spent on the "creations" of Rimmel, Vinolia, Grossmith, Atkinson, Gosnell, Erasmic, and other British makers who have made their wares popular all over the world; while the staples of Continental perfumers like Roger & Gallet, Piver, and Pinaud, and the celebrated Farina eau-de-Cologne must not be forgotten.

Sundries. This may seem a modest estimate for one aiming at doing a high-class business, but it should suffice, for it must not be forgotten that the balance of the £150 will be required—and perhaps a little more—to cover the necessities that remain. These include toilet vinegars, hair washes, hair pomades, hair oils, brilliantines, mouth washes, and liquid dentifrices, tooth pastes and powders, cosmetics for the hair and moustache, creams, pastes, cosmetics and powders for the skin, toilet milks, perfume sprays, perfumed sachets, toilet powders, smelling salts, incense ribbon, fumigating pastilles, manicure sets, shaving creams, and the important section of toilet soaps. All these must be selected in small, assorted quantities (¼ dozens or ½ dozens), the aim being to have as varied an assortment as possible.

Development. As the business grows, the man with a genius for perfumery will soon evolve new notions, and, provided he can hit on a novelty in perfume, to which he can attach an original and striking cognomen (always taking care to endeavour to be unique in the style and finish of their packing), his success, all other things being favourable, is a foregone conclusion. If a new perfume is evolved—and there are thousands put on the market annually—the usual method is to run a series. That is to say, should he produce a perfume which he names "Eunitia," for instance, he would have besides "Eunitia" bouquet in various sized bottles, "Eunitia" toilet cream, "Eunitia" sachet, "Eunitia" face powder, and even "Eunitia" toilet soap. There is great scope for ingenuity in such an occupation, and to the earnest enthusiast the business is a fascinating one. Then the question of face massage and complexion beautifying is becoming yearly more important. As trade increases, a portion of the shop might be curtained off, or the back shop premises converted into a kind of a boudoir, where Society dames may have their jaded complexions renovated by an experienced masseuse with creams and lotions compounded on the establishment. This once attained and a fair connection secured, the business becomes very profitable indeed, for what will not woman sacrifice to maintain her beauty? Some perfumers have chiropody as a side line, but this requires skill, and generally entails the employment of expert and high-priced operators. The art of manicuring, however, is easily acquired, and well repays the time and trouble spent on it. Detailed particulars regarding "Manicuring" and "Massage" will be found on pages 3738 and 3739. For "Chiropody" see page 1895.

Two Representative Formulas. In the course of his tutelage the young perfumer will become acquainted with many formulas or recipes for the preparation of various perfumes. The aim has been and still is to imitate by the combination of various essential oils the perfume of known flowers. In many cases this imitation is very successful, although the most satisfactory perfumes are undoubtedly made by direct abstraction from the real flowers, either by distillation or by enfleurage. The latter process produces the best results, and is done by placing the petals or leaves on fats, either hot or cold. These processes, however, require a special plant, which the retail perfumer would not possess; so he would buy essential oils from a reputable house, lay in a stock of rectified spirit, and make a "Honeysuckle" perfume, for instance, by mixing the following ingredients:

Oil of pimento	10 drams
Essential oil of almonds	10 drams
Oil of cedrat	5 oz.
Oil of origanum	3 drams
Otto of rose	1 dram
Rectified spirit	4 pints

The usual process is to add the oils to the spirit in a large stoppered bottle, shake, and leave to mature for a week or two before bottling. The most popular of the perfumed waters is "Lavender Water," and every perfumer has his own formula for this. A delightful "lavender," and one which is said to have been prepared for and used by George IV. is made as follows:

Mitcham oil of lavender	6 drams
Essence of musk	6 drams
Essence of millefleurs	6 drams
Oil of bergamot	3 drams
Otto of rose	½ dram
Rectified spirit	48 oz.

One of the prime essentials in the preparation of a lavender water is to make sure that a well-matured English oil of lavender is used; and the perfume, after being mixed, should stand for from four to six weeks with occasional shaking, before being filtered through filtering paper. Grey filtering paper of English make should be employed, and the paper should be warmed before the filtering process is begun.

Alluring the Public. A brilliantly-lighted and luxurious window display frequently changed is necessary to attract the public. The vogue of recent years has been to make displays of special perfumes by the use of floral adjuncts, such as baskets of roses, be-ribboned receptacles for perfume bottles, soaps, sachets, etc., palms, greenery, and other elegantly executed pictorial representations of high art, and adjuncts of a like nature, to draw the public to the window. Sprays of honeysuckle in profusion would impress the "Honeysuckle bouquet" on the public mind, and tempt to its sale, while baskets of lilies or twining loops of iris, or other known flower, would be employed for the perfume it represented. The main feature, however, is good taste in all displays, and the lavishly floral or the gorgeously plush may with profit in many instances be replaced with effect by the severely classical, or, as in the case of Old English Lavender, by an old-world touch. On the opening week, tiny sample sachets or sample bottles of a special perfume might be distributed judiciously, and a never-failing attraction and strong incentive to purchase is the practice of having one or two spray bottles containing representative perfumes on the counter or tables in the salon, by means of which the customer may "try before she buy."

Profits. The perfumer will have no difficulty, with a good character and £500 in the bank, in obtaining credit on the usual monthly or three-monthly terms, and he will find, as in most other businesses, that prompt cash brings the largest discounts. Thus, if he pays for his opening stock "on the nail" he will secure from 7½ to 10 per cent. off the list prices—a consideration on a £150 order. The profits on perfumes and toilet articles are good, averaging from 40 per cent. to 50 per cent. on the turnover. Proprietaries do not bear so great a profit—the best-known perfumes and soaps bearing, roughly, 15 per cent. to 25 per cent. profit only. But the bulk perfumes show considerably over 50 per cent. average, and when a formula has been produced that gives a perfume that can be sold in 1-oz. bottles for 2s., for instance, the profits mount up higher still. Taking all things into consideration, however, one might say that a fair average all round may be struck at 50 per cent. on the turnover—a profit by no means to be despised in these times of stores and cut prices.

Continued

THE MINOR SOURCES OF SUGAR

Sugar from the Maple, Palm, and Date. Tapping the Trees. Yields. Sugar-making and Refining in India. Sorghum Sugar and Syrup. Maize Sugar

SUGAR
continued from page 4166

Sources of Maple Sugar. Maple sugar is the produce of several kinds of maple-trees, the following being the chief varieties:

Sugar maple, hard maple, or rock maple—botanical names: *Acer barbatum, Michx., A. saccharinum Wang.*

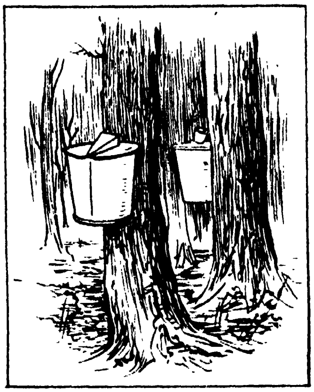
Silver maple, soft maple, white maple or swamp maple—botanical names: *A. saccharinum Linn., A. dasycarpum Ehrh.*

Red maple, soft maple or swamp maple—botanical name: *A. rubrum Linn.*

Black maple—botanical names: *A. barbatum nigrum Sarg., A. saccharinum nigrum T. and G., A. nigrum Mich.*

Production. Maple syrup and sugar have a distinctive delicate flavour, on which account they are much prized in the countries of production—Canada and the United States. The production of maple sugar is looked upon as a remunerative adjunct to other farming industries. The season for tapping begins where winter ends, and is over before the ground is sufficiently thawed and settled for spring work proper. It therefore occupies a period when little other farm work can be done. In Canada some 10,000,000 lb. of maple sugar is made annually, while in the United States the annual production approximates 45,000,000 lb. The bulk of the United States production of sugar and syrup is made in the States of Vermont, New York, Ohio, Pennsylvania, and New Hampshire. The production of maple sugar has been especially encouraged in Vermont, where a bounty was paid on quantities of at least 500 lb. sugar testing 80 degrees or over of the polariscope. The industry was established in Vermont by the Indians, and from them the early settlers learnt the process of manufacture. Between the years 1896 and 1904 the University of Vermont and State Agricultural College conducted a research on maple sugar which has cleared up many doubtful points; this research is the most complete study of the subject that has been made.

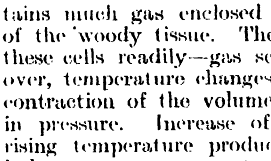
How the Sugar is Obtained. Maple sugar is formed from starch, in the late winter and early spring. This starch is stored in certain sapwood cells during the preceding summer, and is probably transformed into sugar through the action of enzymes (ferments). The starch is formed in the leaves under the influence of sunlight, and a large leaf area and plenty of sunshine conduce to a good sugar yield. As will be explained later, the tree is tapped, and the sap from which the sugar is made flows through the tap into a bucket placed to receive it [16]. The immediate cause of the flow from the tap hole is sap movement under pressure towards the point of least resistance. The exciting cause of the flow seems to be temperature fluctuations backwards and forwards over the 32° F. line, causing alternation of pressure and suction—a pump-like action. The ultimate and absolute cause can hardly be this or any other physical one; it is probably a function of living cell.



16. COLLECTING MAPLE SAP

The maple trunk rapidly accumulates water during the late winter and early spring. It at all times contains much gas enclosed within the cell walls of the woody tissue. The sap passes through these cells readily—gas scarcely at all. Moreover, temperature changes cause expansion, or contraction of the volume of gas, and change in pressure. Increase of water content and rising temperature produce pressure, pressure induces sap movement, and sap movement means sap flow. Pressure and sap flow come from above and below the tap hole, but little from the side.

Season for Tapping. The time for tapping is from the middle of February to late in March, when the nights are still frosty, but sunny and warmer days prevail. If at this time the trunk of the maple be tapped, by boring into it for a depth of 3 in. or less, and a sap spout, or spigot, be inserted, the sap exudes and falls drop by drop, quickly or slowly, according to the weather and time of day, into the bucket. The season lasts well into April. The taps used are figured in **17**, the top two being the simplest kinds; the fourth, the "Foster" tap, is one much in use, the hook being used for suspending the bucket. The collecting pail should be of tin, and have a cover to keep out snow, rain, and dirt, since much extra fuel is needed to evaporate the sap when it is mixed with rain or snow. The pail holds from 16 to 18 quarts of sap.



17. MAPLE TAPS

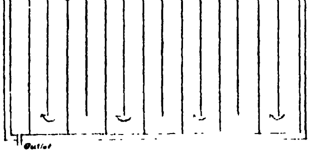
No more sugar is yielded by tapping on the branchy side of the tree than on the side relatively devoid of branches. The hole in the tree

into which the tap is inserted is made with a sharp bit, about four feet from the ground. The larger the tap hole the more sap and sugar, for a time, at least. It is undesirable, however, so to wound the tree that the hole will not soon heal. A $\frac{3}{8}$ to $\frac{5}{8}$ in. bit is best for tapping, and care should be taken to free the hole from shavings and borings before the tap is inserted. The sap is at first quite clear, but as the season advances the flow lessens, and the sap becomes thicker and cloudy.

Yield of Sap. A good sap day, of which there are ten or fifteen in a season, occurs only after the air temperature has remained below freezing point for some time. Warm days and frosty nights form ideal sugar weather. Some 63 per cent. of the sap flows before noon. The total sugar content of a tree carrying 135 gallons of 3 per cent. sugar is approximately 35 lb. The average yield of sugar from a small tree is 3 lb., which represents 9 per cent. of the total sugar content. A pound of sugar from each pail of sap is the usual amount, and is amply maintained in practice. The sap ice should not be discarded, as ice removes much sugar. The duration of the sap flow depends on the weather conditions; it may be fairly continuous for some time, but is commonly broken into distinct runs. The swelling of the leaf buds preparatory to bursting marks the end of the flow, or season.

Trees under 25 years old are seldom tapped, as the yield is too small to pay; but once a tree is tapped the process may be continued annually for forty years, without harm to the tree.

Sugar Boiling. The process of obtaining sugar from maple sap is extremely simple on account of its purity and freedom from extraneous matter. The contents of the sap buckets are emptied into a tank in the boiling shop, and from this tank the sap is led to the evaporator, which is heated by prunings of the maple grove. The evaporator [18] is a large iron pan from 10 to 18 ft. long, 4 to 5 ft. wide, and 6 to 8 in. deep, divided by partitions so that the sap, admitted by a tap regulated by a float, takes a devious course before it reaches the far end. The sap boils furiously, and is skimmed all the time by means of shallow tin skimmers. The incoming sap makes a continuous current throughout the evaporator, and by the time the sap reaches the outlet it is a more or less thick syrup. While hot, the syrup is passed through a felt strainer.



18. EVAPORATOR

Maple Syrup. If the maple sugar be required in the form of syrup, which saves much time and fuel, it is evaporated to a density of 1·325 or 11 lb. of sugar to the gallon, and poured while hot into perfectly clean pans or tins, which are then sealed to keep out the air. Syrup of this strength will not granulate under ordinary conditions. The strength to boil can be gauged by a thermometer. When the thin sap begins to boil, its temperature is about 213° F. As it boils down and becomes thicker the temperature at which it boils rises until towards the end it may be 235° to 240° F. A syrup, if consisting only of sugar and water, boiling at 230° F. would test 80°, and at 253° F. 90° polariscope, and each degree over this temperature approximately one per cent. of sugar.

If made into sugar, the syrup is boiled over a brisk wood fire, in a pan smaller than the evaporator, to a concentration which will crystallise into sugar on cooling. There are various methods of determining when this sugaring point is reached, the usual test being to pour a little of the syrup on to snow, when, if ready, it gives a stringy or hairy product. The pan is then removed from the fire, the mass stirred or dipped until graining begins, and transferred to tubs to harden. Variations in the manufacture are practised, a little lime or soda being, in some cases, added to neutralise free acids, and in others white of egg is used to make a crystal white product.

Palm Sugar. In India, besides the sugar cane, several palms are used as sources of sugar. The chief kinds are:

Palmyra palm or crab tree—botanical name, *Borassus flabelliformis Linn.*

Indian date palm—botanical name, *Phœnix Sylvestris.*

Sago palm—botanical name, *Caryota urens.*

Coconut palm—botanical name, *Cocos nucifera.*

Neem tree—botanical name, *Melia azadirachta.*

The Palmyra Palm. The Palmyra palm constitutes the only species of the genus palmacea, the word *flabelliformis* referring to the fan-shaped leaves. It is very widely distributed, and is found in South America and Australia, and in every part of Hindustan. The average height of the tree in Tinnevelly is 40 to 50 ft., the circumference at the base being often 5¾ ft., and at the top 2½ ft. The roots penetrate to a great depth, and hence deep loose soil is best for the growth of the tree. The cultivation is easy, it being required simply to collect and sow the seeds, which germinate readily, and to protect the young saplings from cattle and from villagers, who collect and use the young shoots as a vegetable. The tree cannot stand very much drought, and is best planted in a rather damp locality.

Method of Collecting the Sap. The saccharine juice of the Palmyra palm is obtained by bruising the flower stalk with a wooden instrument resembling a pair of compasses so as to crush the embryo flower or fruit within, and by taking a thin slice off the end for several days. The object of slicing the end of the spathe is to facilitate the exit of the sap, and to prevent it from bursting the spathe. About the eighth day the sap begins to exude, and is received in a little earthen vessel attached to the stalk. The inside of this vessel is smeared with chunam to prevent the juice fermenting. The tree is climbed both morning and evening for bleeding,

but the sap which has collected since the last ascent is usually brought away in the morning only. The quantity of juice yielded by a male tree is about two-thirds of that obtained from a female tree. The palmyra season extends from the beginning of February to the beginning of October. Much of the fermenting sap is drunk just as it comes from the tree, and when allowed to ferment forms the intoxicating beverage known as *toddy*. Still more of the juice is boiled into *jaggery*, or converted into *sugar candy*.

The palmyra continues to yield three or four quarts of sap a day for four to five months, but once in every three years the operation of tapping must be suspended, and the fruit permitted to form, otherwise the tree would die. The juice contains more sugar than other palms, three quarts of juice yielding one pound of jaggery. The tree goes on yielding juice for about fifty years, and begins to give sap when about 15 years old, but this depends upon the locality. The production of sugar from the sap is dealt with in the section devoted to the date palm.

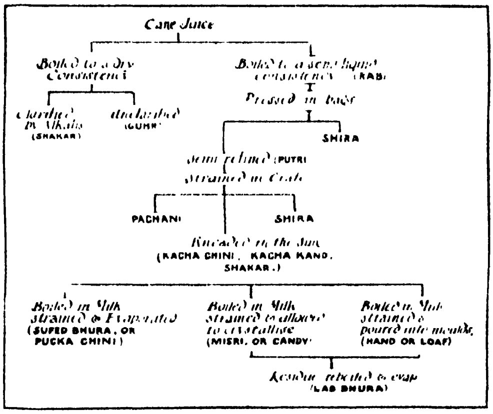
Indian Date Palm. The date palm attains a height of 30 to 40 feet. It grows most abundantly in Bengal, Behar on the Coromandel coast, and Guzeràt. In Jessore and other districts of Bengal, it is extensively utilised as a source of sugar. The higher ground is that chosen for date palm cultivation, and the seed is planted in rows 12 ft. apart. After seven years a tree ready for tapping is obtained, the process being repeated thenceforward every year. There are two series of leaves, the crown leaves, which rise straight from the top of the trunk, and the lateral leaves, which spring out at the side of the top part of the trunk. When the rainy season has completely passed, and there is no more fear of rain, the cultivator cuts off the lateral leaves half round the tree, thus baring a surface measuring 10 to 12 in. each way. This surface, at first white and afterwards turning brown, is not the woody fibre of the tree, but is a bark formed of many thin layers which change colour.

Tapping the Date Palm. After the tree has remained for a few days, the tapping is performed by making a cut into this exposed surface in the shape of a very broad V, about 3 in. across, and $\frac{1}{4}$ to $\frac{1}{2}$ in. deep. Then the surface inside the angle or V is cut into, so that a triangular surface is obtained from which sap flows. The sap flows to the bottom of the angle of the V, where a small bamboo spout is placed to convey it to a small earthenware vessel. The tapping is arranged throughout the season by periods of six days. On the first evening a cut is made as described, and the juice allowed to run during the night, this juice being the strongest, and known as *jiran* juice. In the evening another slice is cut off the exposed surface, the sap obtained being termed *do-kat*. No new cut is made on the third night, the juice which runs out being called *jarra*. The tree is then rested three nights, and again tapped as described above. In time the tree gets a depth of four inches taken out of the wound. The following season, the opposite side of the tree is tapped, each tree yielding juice for about forty years. The notches are always on the east and west sides of the tree. The clearer and colder the weather, the more copious the flow. Tapping begins in November, the best flows being in December and January. The flow diminishes as the warm weather comes. Each tapping yields five *seers* of juice on the average, and seven to ten seers produce the *seer of guhr*.

The annual yield of sugar from palm-trees in India is estimated at 100,000 tons.

Other Sugar-yielding Trees. The *sago palm* of India is the chief source of palm sugar in Southern Ceylon, and in the Bombay Presidency more sugar is made from it than the palmyra palm. The *coco-nut* palm is used as a source of sugar in Madras, while only a small quantity of sugar is obtained from the *Neem* tree.

Sugar-making in India. The processes followed in making sugar from cane juice are shown in the table prepared by Mr. T. O. Miller for the "Agricultural Ledger." It is given here [**19**] to show the great varieties of sugar which are prepared from one source, and also because some of the methods are followed in preparing sugar from the sap of the Palmyra palm and Indian date palm.



19. TABLE OF INDIAN SUGARS

The juice from the palm is boiled at once in large pots placed in a hole on the top of a dome of brickwork which is over a wood fire. The fire is kept burning by using the leaves of the trees with the wood fuel. The juice is clear when put into the pan, but after boiling turns dark brown, and yields a semi-solid mass called *guhr*. This, when still warm, is poured into small earthenware pots. It takes two and a half hours to boil a panful of juice to the guhr condition.

The refining processes of India do not involve the use of charcoal, but consist of eliminating the molasses more or less perfectly by draining, reboiling, and claying. The cane-juice table sufficiently explains the general methods followed in the case of palm sugars. The English system is also followed to a limited extent. It should be noted that the greater purity of the palm juices makes the refining a less troublesome operation than in the case of cane juice; it is also cheaper.

Sorghum Sugar. Broom corn, Chinese sugar cane, Imphee or Sorgho—botanical name, *Sorghum saccharatum Pers.*—is a graminaceous plant which has been the subject of much experiment as a sugar producer [20]. Experiments in Kansas have shown that sorghum may be developed in any particular direction by continuous selection of seed from cane which has the qualities desired. In this way the percentage of sugar might be increased and the proportion of impurities in the juice diminished.

20. SORGHUM

No sugar, or only a very little, is produced from sorghum at the present time, but a considerable quantity of sorghum syrup is manufactured. The difficulty has been to get rid of the starch and gummy matters, and the uncrystallisable sugars which prevent the sugar from being prepared in a dry state. The juice of the sorghum contains about 10 per cent. of sugar. A variety of sorghum (*S. vulgare Pers.*) or great millet, also yields sugar.

Cultivation of Sorghum. Sorghum as a source of seed for cattle-feeding purposes is considered by some experts to be superior to maize, and it is probable that future investigation may result in varieties which yield a maximum of sugar as well as fully-matured seeds. The varieties at present best known are the Honduras, early amber or early golden, and white Liberian. The stalk is $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. in diameter, and from 6 to 12 ft. long. Sorghum is not affected by drought and can be grown on any good corn land. The land should be deeply ploughed and freed from lumps in the spring by rolling or harrowing. Planting should not be too early, but in warm and moist soil, so that the plants appear in a few days. The plants may be thinned, and are best planted in hills, so as to be able to stand the wind better. Close planting checks the growth of weeds, but exclusion of light is deleterious to the growth.

The time required for maturing varies from 90 days in the case of the early amber, to 140 days for Honduras. The time for harvesting is when the seed has passed the doughy stage and feels hard. The tops are removed by a sickle for the sake of the seed, and sometimes the stalks are stripped for fodder, but there is no difference in sugar yield between stripped and unstripped stalks. It is important to reject immature canes as the larger proportion of glucose they contain prevents the crystallisation of the sugar.

Collier emphasises the following points:

1. A cane that matures quickly and has as long a working period as possible should be selected.

2. The cane should not be worked too early; the seed should be well matured and quite hard, and the juice should have a specific gravity of at least 1·066.

3. After cutting, the canes should be worked up without delay. It is best to draw directly from the field to the mill, as required, to keep the mill going.

The stalks are passed through rollers as in the case of the sugar cane, the juice is then limed, defecated, sulphured, and concentrated in much the same way as for Beet Sugar [page 4160].

Sorghum Syrup. The United States Department of Agriculture has issued in a popular form a pamphlet dealing with the production of sorghum syrup, of which the following is an abstract of the practical portions. The juice as it comes from the mill is treated with sufficient cream of lime to render it slightly alkaline when tested with litmus paper. Excess of lime should be avoided. The addition of fine clay at this stage is also recommended. The clay, in very fine powder, is stirred in water to make it into a thin batter, and a small quantity of this is stirred in after the lime. The lime and clay gradually subside and take down with them the impurities of the juice. The vessel containing the juice is allowed to remain undisturbed until the juice is cleared. The clear juice is then drawn off, heated nearly to boiling point, and a little superphosphate of lime added to make the liquor distinctly acid to litmus paper. About a gallon of concentrated superphosphate of lime is sufficient for from 400 to 500 gallons of juice, the quantity depending upon the amount of lime that was used. Excess of superphosphate must not be added, as it affects the taste of the product. The mixture settles out a precipitate from which the clear juice is separated and rapidly concentrated in an evaporator. Bright and brilliant clarified juice is essential to success. After evaporation to a suitable density the syrup is cooled, and when it reaches the temperature of the air it is put into barrels. If no clay be used in the process of manufacture, the juice is slowly heated after the addition of lime and the scum that forms removed by a skimmer. The juice may have a little bisulphite of lime added at this stage as a preservative and colour improver. After the juice has been thoroughly skimmed it is allowed to settle for from one to two hours, the clear juice being drawn off from the sediment and evaporated very rapidly into a syrup.

Maize Sugar. The stalks of Indian corn, *zea mays*, contain from 9 per cent to 12 per cent. of sugar, and have been used as a source of sugar by the Mexicans in ancient times. The taste of the syrup or sugar obtained from maize resembles that of maple sugar.

Sugar cannot be made from maize to compete profitably with that of the beet, but it is quite possible that a systematic selection of seed according to the sugar yield would give better results. It would be an ideal state of things if the corn could be grown both for its seed and sugar.

Continued

LITTLE BOYS' SUITS

The Drafting and Making of a Man-o'-war Suit. The Jumper and Whole-fall Trousers. Sleeves and Pockets

CHILDREN'S CLOTHING continued from page 4196

By AZÉLINE LEWIS

THE shape of the first small shirt cut on manly lines is shown in **37**, and is made in practically the same way as the grown-up model, for which we must refer the maker to SHIRTMAKING, where full directions are given. The yoke is of double material, cut selvedgeways, and is stitched to the gathered back, as the notches indicate. The button stand is stitched to the right side of front opening, and the mitred wrap on the left, as it must be remembered that men's garments fasten over from left to right, and not right to left, as those of the other sex. This shirt will take 1 yd. of 36-in. material, either of flannel or shirting.

The pattern can also be utilised for the French shirt shown in (*b*) of **36**, the lower portion being merely elongated and cut leg-fashion. As already mentioned, if these be further extended, and the garment made larger, it forms an excellent sleeping suit.

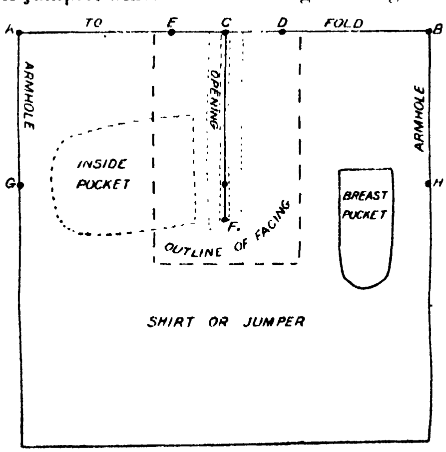
Man-o'-war Suit. The drafting and making of this suit are given in full, as they present a few variations, and the style is always popular. Besides this, the small trousers can be adapted to several shapes. The measurements are as follows: Breast, 26 in.; neck, 12 in.; sleeves, 14 in.; wrist, 6 in.

This drafting will do for four years, as already observed, by cutting without inlays. The materials and accessories required for this suit are $2\frac{1}{4}$ yd. of 27-in., or $1\frac{1}{8}$ yd. of 50-in. material; $\frac{3}{8}$ yd. flannel for singlet; lanyard and whistle; black silk square; man-o'-war hat.

Diagram **38** shows the jumper, which is drafted as follows: A to B, two-thirds of breast (about $17\frac{1}{4}$ in.); make C in the centre. Draw two parallel lines from A and B, 18 in. in length (or longer if desired).

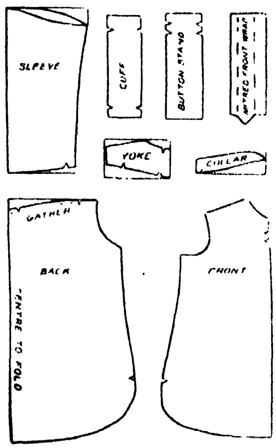
C to D, and C to E are each one-sixth of the neck measure, plus $\frac{1}{4}$ in. ($2\frac{1}{4}$ in.); C to F, one-fourth of breast, plus $1\frac{1}{2}$ in. (8 in.); A to G, and B to H, are each one-fourth of breast ($6\frac{1}{2}$ in.).

THE COLLAR. A to B, the neck measure, less 1 in.; C midway between; the depth of collar is one-fourth of breast plus 1 in. ($7\frac{1}{2}$ in.), or deeper if desired. [See diagram **29** (2)]



38. JUMPER

SLEEVE. A to B, one-fourth of breast plus 2 in. for pleats ($8\frac{1}{2}$ in.); A to C, the length of sleeve (14 in.); C to D, half wrist plus 2 in. for pleats; connect D to B; B to E, 1 in.; connect E to A [**41**].



37. SHIRT

THE SINGLET. A to B and A to C are each one-sixth of neck, less $\frac{1}{4}$ in., to make it fit well round the neck; A to D, $1\frac{1}{2}$ in. Curve from B through D to C. D to E and D to F are each 5 in.; D to G, 10 in.; H and I are each $2\frac{1}{2}$ in. from G. Draw lines from I to F on to C, and from H to E on to B. A represents the back, and D the front [**40**].

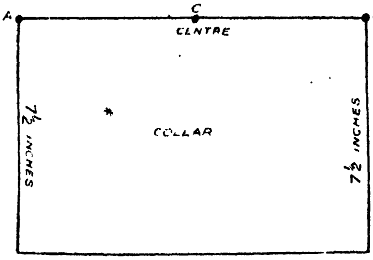
In cutting out the pattern, allow $\frac{1}{2}$ in. turnings. The shirt, or jumper, as the sailors call it, is cut in one piece—*i.e.*, it has no shoulder seams, these being placed to the fold of material.

The Making. Chalk-mark the armholes, as at G and H; then slit the neck from E to D, and mark the opening from C to F, or longer if required, to allow plenty of room for the head to go through, and avoid splitting. The opening must be faced with a strip of the same material 6 in. wide and $1\frac{1}{2}$ in. longer than opening. Chalk-mark the centre of facing, as from C to F [**38**].

The making of the jumper is very simple. The facing is stitched to the inside of front, as shown by the broken lines, using a long stitch for coarse material, and well pressed. Make a small pocket and sew on the inside of right fore part on the edge of facing [**38**], and another on the outside of the left fore part for whistle, etc.

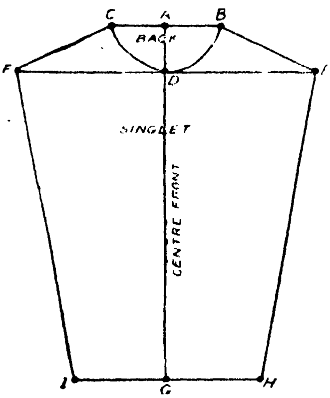
For the collar, two pieces must be cut out, and $\frac{1}{4}$ in. turnings allowed all round. It is made in the same manner as a pocket-flap, for which see BOYS' TAILORING [page **1292**]. Insert the neck of jumper between the collar, placing centre of neck to centre of collar; baste on carefully and

stitch along the neck and all round the collar, quite close to the edge, and ¼ in. beyond. Press well on the wrong side, over a damp cloth. The seams can now be basted together and stitched; remove the basting and stitch again on the right side through both turnings—*i.e.*, without opening the seam —¼ in. from the seam, to keep them flat and neat; turn up the bottom, baste, and stitch.



39. COLLAR

The sleeve should have a box pleat in the centre of top, and one on either side, reversed—*i.e.*, one facing front, the other back; 2 in. are allowed for the pleats, and they should be stitched down 2 in. or more to keep in position. The wrist is made in the same manner. After the pleats are stitched, the bottom should be turned in ¼ in. and faced with a piece of material or lining, and the opening of sleeve hemmed—about 3 in. will be sufficient. Then stitch up the seam to match the sides, place a button on the under part, and work a buttonhole in the top. The sleeve can be made without an opening if preferred; in this case, the seam must be stitched before the facing is put on.

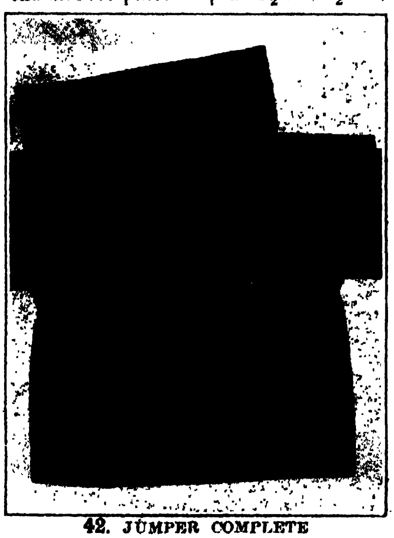


40. SINGLET

Diagram **42** shows the shirt finished and the position of pockets. To insert the sleeve, place the seam to the underarm seam, baste and stitch; turn the shirt on the right side, and stitch again, to match the other seams. Sew two pieces of ribbon on the opening, about 1 in. from the bottom.

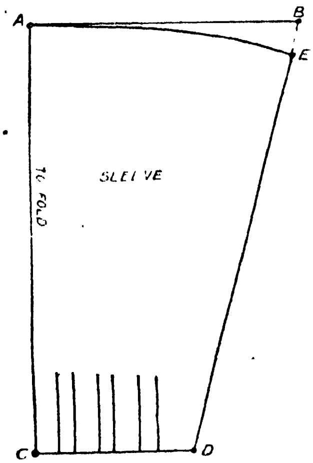
Drill collars to wear over these jumpers are sold ready-made, or can be made as shown.

The singlet is cut in two pieces. Join the right shoulder, turn in the edges of the left, work two buttonholes or loops on the front, and sew two buttons on the back; the neck should be bound round with a strip of drill or linen, cut on the cross, whilst the edges can either be bound, or turned in and herringboned. Sew tapes at each corner, to keep the singlet down when worn. An anchor on the centre of front is a great improvement, and can be bought woven ready to sew on.


42. JUMPER COMPLETE

Drafting "Whole-fall" Trousers. These are the measurements: Inside leg, 16 in.; waist, 26 in.; seat, 28 in. Working scale, half seat, 14 in. [**43**]. These trousers are cut without an outside seam, so the paper for drafting must be folded in half lengthwise.

A to B, the inside leg measure, 16 in.; B to C, half scale, 7 in.; C to D, one-fourth, 3½ in.; C to E, half the distance from C to D, 1¾ in.; E to F, 1 in.; C to G, half scale plus 1½ in., 8½ in.; square a line from G to the fold, and make H. H to I, 4 in. (for the opening); H to J, 2 in.



41. SLEEVE

Square out from J half the waist measure, 6½ in., and make K; K to L, 1 in.; connect J to L. Draw line from L to F, and curve from F to D; curve gradually from ½ in. to the left of G, through E to D. We must now consider the leg. A to M, half the inside leg measure plus 1½ in., 9½ in.; M to N, half the seat measure, 7 in., more or less as desired; A to O, 1 in. more than M to N [**43**]. Curve from O through N to D. The bottom should be slightly rounded.

Cut out the pattern from L, through F to D, thence through N to O, and on to A [**43**]. Next, slit down the opening from J to I, cut along the fall from H to G, and ½ in. to the left of G, through E to D.

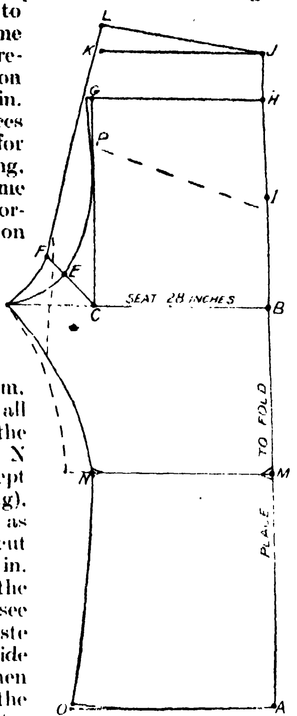
It must be remembered that the pattern is drafted double, no seam being required at side, so care must be taken in cutting-out the upper front portion when the slit for the fall has been made not to cut the back part too.

Two pieces are required to go under the fall, which correspond with the upper part of front; these are joined on

at the sides, to finish the waist part; and to this the fall is buttoned. They are cut as shown in diagram **44.** I to J and J to K must be the same measure as corresponding letters on drafting. K to P, 4 in.

Two small pieces are also required for the fall-front facing, and are the same measure as the corresponding letters on the drafting.

Open the pattern of trousers on to the material, each leg being cut without a side seam, chalk-mark all round, as also the knee-marks at N (these are to be kept together in making), and the opening as at H and I, and cut out, allowing ¼ in. turnings. Face the forks with lining [see TAILORING]. Baste and stitch the inside leg seams; then baste and stitch the two back parts together, beginning two inches from the waist and terminating at the top of fall, as at G, taking care to keep the forks together, as at D. This part must be faced with two pieces of lining. [For shape see broken line in the drafting.]

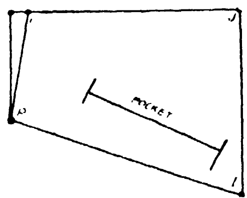


43. "WHOLE-FALL" TROUSERS

Cut two pieces of material or lining (in many cases the latter will prove much less clumsy), join the centre and hem the lower edge; place the facing on the fall, face to face; baste and stitch round the edge, turn it over to the wrong side, work out the corner, baste again, and stitch ¼ in. from the edge. Join the small pieces to the sides, placing J and I together; turn in the top of waist ½ in., and face with a straight piece of lining; this must be slip-stitched all round.

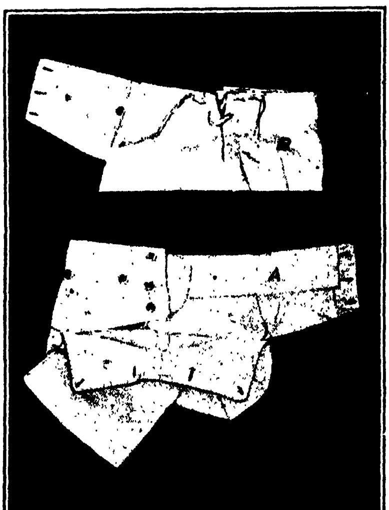
Turn back the 1½ in. for buttons and buttonholes, and hem along the bottom. Stitch all round the top of waist and edge of fronts, ½ in. from the edge; secure the openings with a double row of stitching. Work four buttonholes on the fall, one at either corner (on the slant), and one about 1½ in. on either side of the seam, and three on the left under part [see A in diagram **45**].

As the blouse in this suit is tucked inside the trousers, no braces can be worn. The absence of this support, is, however, arranged for by drawing them together at the back by means of ribbon, or a lace passed through eyelet-holes. For this, the back seam is left open a few inches from the waist, and firmly fastened off to prevent tearing. For woollen material, it is best to stitch the opening about ¼ in. from the edge, but for drill or cotton it is not necessary. Two eyelet-holes are then worked with twist on each side of the opening. [For the method of working, see DRESSMAKING.] Now baste a piece of lining or material on the inside of the opening, about 4 in. square, and rounded at the lower part, forming a pocket-shaped piece, which stitch round twice [see B in diagram **45**]. This facing is to prevent any discomfort or pressure from the ribbon or lace used to draw it in the waist. For this last purpose a short silk or mohair bootlace answers admirably, but ribbon can be used if preferred. For the position of the facing, see diagram **45**, which shows the waist part of the trousers complete. In A we have the fall-front showing facings and buttonholes; also position of buttons on the pieces which go under the fall. In B, the back part is shown finished.



44. FRONT WRAP

Turn the fall over the front and mark position for the buttons, also for those on the right front; sew them on; turn up the bottom and fell and press.



45. TROUSERS COMPLETE

If a pocket is wanted, it should be jetted; for position see diagram **43.** Full directions for making pockets were given in TAILORING FOR WOMEN [page 1844].

This drafting can easily be converted into knickers, if required, by cutting pattern to the knee-line, and widening the leg part, as shown by the broken line.

If made a little fuller at the knee part, which can easily be done by placing J of the drafting to the fold of material, and M ½ in. in from this, the pattern will do for the gathered knickers worn with the tunic suits. If required with openings in front, we must refer the maker to the section on BOYS' TAILORING [pp. 1431, 1551], although, of course, the correct pattern to be worn with this suit is that illustrated on this page.

Continued

ITALIAN—FRENCH—GERMAN—SPANISH

Italian by F. de Feo; French by L. A. Barbé, B.A.; German by P. G. Konody and Dr. Osten; Spanish by A. de Alberti and H. S. Duncan

ITALIAN Continued from page 4216 By Francesco de Feo

VERBS—continued

Reflexive Verbs

THE reflexive form of the active verb is obtained by the addition of the conjunctive forms of the personal pronouns *mi, ti, si, ci, vi.* [See page 3784, Position of the Conjunctive Forms.] The reflexive verbs are conjugated with the auxiliary *èssere.* The past participle must always agree in gender and number with its subject.

Lavarsi, to wash oneself

INDICATIVE MOOD

Present

io mi lavo, I wash myself
tu ti lavi, thou washest thyself
egli si lava, he washes himself
noi ci laviamo, we wash ourselves
voi vi lavate, you wash yourself, -selves
essi si làvano, they wash themselves

Past Indefinite

io mi sono lavato, -a, I have washed myself
tu ti sei lavato, -a, thou hast washed thyself
egli si è lavato, he has washed himself
noi ci siamo lavati, -e, we have washed ourselves
voi vi siete lavato, -a, -i, -e, you have washed yourself, -selves
essi si sono lavati, they have washed themselves

Imperfect

mi lavavo, I washed myself
ci lavavamo, we washed ourselves

First Pluperfect

mi ero lavato, -a, I had washed myself
ci eravamo lavati, -e, we had washed ourselves

Past Definite

mi lavai, I washed myself
ci lavammo, we washed ourselves

Second Pluperfect

mi fui lavato, -a, I had washed myself
ci fummo lavati, -e, we had washed ourselves

Future

mi laverò, I shall wash myself
ci laveremo, we shall wash ourselves

Future Perfect

mi sarò lavato, -a, I shall have washed myself
ci saremo lavati, -e, we shall have washed ourselves

IMPERATIVE

Present

làvati, wash thyself
laviàmoci, let us wash ourselves
Third person: *si lavi* (sing.); *si làvino* (plur.).
Second person plural: *lavàtevi.*

SUBJUNCTIVE MOOD

Present

che io mi lavi, that I wash myself
che noi ci laviamo, that we wash ourselves

Perfect

che io mi sia lavato, -a, that I have washed myself
che noi ci siamo lavati, -e, that we have washed ourselves

Imperfect

se io mi lavassi, if I washed myself
se noi ci lavàssimo, if we washed ourselves

Pluperfect

se mi fossi lavato, -a, if I had washed myself
se ci fòssimo lavati, -e, if we had washed ourselves

CONDITIONAL MOOD

Present

mi laverei, I should wash myself
ci laveremmo, we should wash ourselves

Perfect

mi sarei lavato, -a, I should have washed myself
ci saremmo lavati, -e, we should have washed ourselves

INFINITIVE MOOD

Present

lavarmi, -ti, -si, -ci, -vi, to wash myself, etc.

Perfect

èssermi, -ti, -si, -ci, -vi lavato, -a, -i, -e, to have washed myself, thyself, etc.

GERUND

Present

lavàndomi, -ti, -si, -ci, -vi, washing myself, etc.

Perfect

essèndomi, -ti, -si, -ci, -vi lavato, -a, -i, -e, having washed myself, etc.

PARTICIPLE

Present

lavàntemi, -ti, -si, -ci, -vi, washing myself, etc. (unused).

PAST PARTICIPLE

lavàtomi, lavàtami, etc.; *lavàtici, lavàteci, lavàtisi,* etc., having washed myself, etc. (of little use).

Many verbs in Italian may be conjugated with *mi, ti, si, ci, vi* in the same way as the reflexive verbs, in order to give more strength to the expression. Such verbs are called Pronominal Verbs, and must not be confounded with the reflexive verbs. Examples: *Avevo tanta fame che mi son mangiato* (instead of *ho mangiato*) *un pezzo di pane intero,* I was so hungry that I ate a whole loaf of bread; *Mi son comprato* (instead of *ho comprato*) *un bel vestito,* I have bought (myself) a nice suit.

When the verb conjugated with *ci*, *vi*, *si* expresses the action of two or more subjects, acting the one on the other, the verb is called *reciprocal*. Examples: *Noi ci amiamo*, We love one another; *Esse si scrivono tutti i giorni*, They write to one another every day.

It should be noted that many verbs which are reflexive in Italian are used in English as intransitive verbs. Examples: *Io mi rallegro*, I rejoice; *Io mi maraviglio*, I wonder.

The following are some of the most important verbs which are reflexive in Italian but not in English:

accòrgersi, to perceive, *mi accorgo di*
addormentarsi, to fall asleep, *mi addormento*
affrettarsi, to make haste, *mi affretto a*
avvicinarsi, to approach, *mi avvicino a*
dimenticarsi, to forget, *mi dimèntico di*
fidarsi, to rely upon, to trust, *mi fido di*
farsi, to become, *mi fàccio*
fermarsi, to stop, *mi fermo a*
indirizzarsi, to apply to, *m'indirizzo a*
informarsi, to inquire, *m'informo di*
lagnarsi, to complain, *mi lagno di*
levarsi, to get up, *mi levo*
pentirsi, to repent, *mi pento di*
sedersi, to sit down, *mi seggo (su)*
servirsi, to use, *mi servo di*
andàrsene, to go away (from somewhere)
Io me ne vado, I go away (thence)
andiàmocene, let us go away (hence)
se ne sono andati, they have gone away (from here, there)

EXERCISE XXXIII.

1. Vestìtevi sùbito, perchè dobbiamo andàrcene. 2. Vi divertiste ieri sera a teatro? 3. Non vi avvicinate troppo alla gàbbia. 4. Incomincio a stancarmi; fermiàmoci un poco. 5. Se vuole lavarsi le mani, le darò dell' acqua calda. 6. I signori del secondo piano si sono lagnati del servìzio. 7. Svegliàtemi alle sette e mezzo domani. 8. A che ora si leva ordinariamente? 9. Si levi; è molto tardi. 10. Vi ricordate di quella signora che era con noi in campagna l'estate scorsa? 11. Me ne ricordo benìssimo. 12. Non bisogna mai pèrdersi d'ànimo nella sventura. 13. Si segga, signora, e mi racconti tutto apertamente: lei sa che di me può fidarsi. 14. Mi ascolti, signore, e vòglia il cielo che non venga un giorno in cui si penta di non avermi ascoltato (m.).

IRREGULAR VERBS

Second Conjugation

Verbs in -ére (long)—continued

Cadére, to fall

Ind. Pres.—Cado, cadi, cade, etc.

Past Def.—Cadai, cadesti, cadde, cademmo, cadeste, càddero.

Future.—Cadrò, cadrai, cadrà, cadremo, etc.

Subj.—Cada, cada, cada, cadiamo, etc.

Condit.—Cadrei, cadresti, cadrebbe, cadremmo, etc.

Past Part.—Caduto.

Conjugate like *cadére*: *accadére* (imp.), to happen; *decadére*, to decay.

Sedére, to sit down

Ind. Pres.—Siedo and *seggo, siedi, siede, sediamo, sedete, sièdono* and *sèggono.*

Imperf.—Sedevo, sedevi, etc.

Past Def.—Sedei and *sedetti, sedesti*, etc.

Future.—Sederò, sederai, etc.

Imperat.—Siedi, sieda and *segga*, etc., *siedano* and *sèggano.*

Subj. Pres.—Sieda and *segga*, etc., *sièdano* and *sèggano.*

Past Part.—Seduto.

NOTE. When the accent falls on the first *e* of this verb, this *e* is changed into *ie*: *siedo, sièdono*; but *sedète, sederò.*

Conjugate like *sedére*: *possedére*, to possess; *soprassedére*, to supersede.

Rimanére, to remain

Ind. Pres.—Rimango, rimani rimane, rimaniamo, rimanete, rimàngono.

Imperf.—Rimanevo, rimanevi, etc.

Past Def.—Rimasi, rimanesti, rimase, rimanemmo, rimaneste, rimàsero.

Future.—Rimarrò, rimarrai, etc.

Imperat.—Rimani, rimanga, etc., *rimàngano.*

Subj. Pres.—Rimanga, rimanga, rimanga, rimaniamo, rimaniate, rimàngano.

Subj. Imperf.—Rimanessi, etc.

Condit.—Rimarrei, rimarresti, etc.

Past. Part.—Rimasto.

Persuadére, to persuade

Ind. Pres.—Persuado, persuadi, etc.

Past Def.—Persuasi, persuadesti, persuase, persuademmo, persuadeste, persuàsero.

Future.—Persuaderò, etc.

Past Part.—Persuaso.

Conjugate like *persuadére*: *dissuadére*, to dissuade.

Tacére, to be silent

Ind. Pres.—Tàccio, taci, tace, taciamo, tacete, tàcciono. (The forms *tàcio, tàciono* are incorrect.)

Imperf.—Tacevo, tacevi, etc.

Past Def.—Tacqui, tacesti, tacque, tacemmo, taceste, tàcquero.

Imperat.—Taci, tàccia, etc.

Subj. Pres.—Tàccia, tàccia, tàccia, taciamo, taciate, tàcciano.

Subj. Imperf.—Tacessi, tacessi, etc.

Past. Part.—Taciuto.

Piacére, to please

Ind. Pres.—Piàccio, piaci, piace, piacciamo piacete, piàcciono.

Imperf.—Piacevo, piacevi, etc.

Past Def.—Piacqui, piacesti, piacque, piacemmo, piaceste, piàcquero.

Subj.—Piàccia, piàccia, etc.

Past Part.—Piaciuto.

The compound tenses are formed with *èssere*: *sono piaciuto*, I have pleased.

Conjugate like *piacére*: *dispiacére*, to displease.

The verbs *piacére* and *dispiacére* are generally used as impersonal verbs, thus: *Mi dispiàce*, I am sorry; *ci dispiace*, we are sorry, etc. *Mi piace*, I like; *gli piace*, he likes; *Le piàcciono questi fiori* ? Do you like these flowers ? etc.

Giacére, to lie down

Ind. Pres.—Giàccio, giaci, giace, giaciamo, giacete, giàcciono.

Past Def.—Giacqui, giacesti, giacque, giacemmo, giaceste, giàcquero.

Imperat.—Giaci, giàccia, etc.

Subj. Pres.—Giàccia, etc., *giaciamo, giaciate, giàcciano.*

Past Part.—Giaciuto.

Valére, to be worth

Ind. Pres.—Valgo, vali, vale, valiamo, valete, vàlgono.

Imperf.—Valevo, valevi, valeva, etc.

Past Def.—Valsi, valesti, valse, valemmo, valeste, vàlsero.

Future—Varrò, varrai, varrà, varremo, etc.

Imperat.—Vali, valga, valiamo, valete, vàlgano.

Subj. Pres.—Valga, valga, valga, valiamo, valiate, vàlgano.

Condit.—Varrei, varresti, etc.

Past Part.—Valso and *valuto.*

Conjugate like *valére*: *equivalére*, to be equivalent; *prevalére*, to prevail (*past part.*, *prevalso*); *invalére*, to become prevalent (*past part.*, *invalso*.)

EXERCISE XXXIV.

1. Questo quadro non vale niente. 2. Tacete, le vostre parole non vàlgono la pena di èssere ascoltate. 3. Io tàccio sùbito, ma è certo che voi non mi persuaderete a fare quello che non mi piace di fare. 4. Mi dispiacque tanto che lei non rimase con noi l'altra sera. 5. Cadde, ma non si fece male. 6. Non vada così presto, rimanga ancòra un poco. 7. Non posso dare di più, ecco tutto ciò che posseggo. 8. Sappiamo quanto vàlgono le vostre promesse. 9. Lo persuasi di accettare l'impiego che gli fu offerto. 10. Se questa càmera non le piace, gliene darò un' altra.

ESERCÍZIO DI LETTURA—continued

Quel brav' uomo aveva lasciato un figliuolo di stampa ben diversa[1]. Or dunque, alla raccolta[2], il cercatore andò per riscòtere la metà ch'era dovuta al convento; ma colui se ne fece nuovo affatto[3], ed ebbe la temerità di rispòndere che non aveva mai sentito dire che i cappuccini sapèssero far noci. Sapete ora cosa avvenne ? Un giorno (sentite questa), lo scapestrato[4] aveva invitato alcuni suoi amici dello stesso pelo[5], e, gozzovigliando[6], raccontava la stòria del noce, e rideva dei frati. Quei giovinastri ebber voglia d'andàr a vedère quello sterminato mùcchio di noci; e lui li mena su in granàio[7]. Ma sentite: apre l'ùscio, va verso il cantùccio[8] dov'era stato riposto il gran mùcchio, e mentre dice: guardate, guarda egli stesso e vede . . . che cosa ? Un bel mùcchio di fòglie secche di noce. Fu un esèmpio questo ? E il convento, invece di scapitare[9], ci guadagnò; perchè, dopo un così gran fatto, la cerca delle noci rendeva tanto, tanto, che un benefattore, mosso a compassione del pòvero cercatore, fece al convento la carità d'un asino, che aiutasse a portàr le noci a casa. E si faceva tant'òlio, che ogni pòvero veniva a prènderne, secondo il suo bisogno; perchè noi siamo come il mare, che riceve acqua da tutte le parti, e la torna a distribuire a tutti i fiumi.

NOTES. 1. Of a quite different character. 2. Harvest. 3. But he pretended to know nothing at all about it. 4. Scatter-brains. 5. Brother spirits. 6. To carouse. 7. Garner. 8. Corner. 9. Instead of losing.

CONVERSAZIONE

A che ora si leva abitualmente ?

Alle sette sono già in piedi: mi levo sempre molto presto.

Io invece sono molto pigro, lo confesso. La mattina non so come decìdermi a saltàr giù dal letto. Se devo uscire alle nove, per esèmpio, alle otto e mezzo sono ancòra lì; e quindi appena ho il tempo di lavarmi e vestirmi.

È una gran brutta abitùdine la sua. Oltre a rovinarsi la salute, perde le più belle ore del giorno. Le ore del mattino hanno l'oro in bocca, dice il provèrbio.

Lei ha ragione, e le prometto di corrèggermi.

Ma si segga, signore.

Gràzie; non posso fermarmi di più.

Ripasserò di qui questo dopo pranzo e le porterò i due romanzi di cui le parlai.

Non se ne dimèntichi, perchè non ho niente da lèggere.

KEY TO EXERCISE XXXII.

1. We were speaking of you. 2. You are very kind. 3. Be so kind as to give me that pin. 4. Excuse me for not having sent them to you earlier. 5. I assure you that I shall do something regrettable if you do not tell me at once the name of that man. 6. You are wrong, my friend; ask your sister; is it not true, Miss N., that you are informed of everything ? 7. You are very ready to speak without being questioned. 8. You are the most genial person I have ever known; how do you manage to be always so cheerful ? 9. Your brother told me that you had returned to town, and I have hastened to come to shake hands with you. 10. Have you enjoyed yourself these long winter months ? 11. Why do you stand at the door in the cold ? Come in. 12. You do not know, and never will know how sincere my friendship for your son was. 13. Have the kindness to put this letter into the post, when you go out. 14. I thank you very much for the beautiful flowers you have sent me. 15. You believe that everything can be done offhand; but time is wanted for everything. 16. Your friends beg you to go down in the garden, if you don't mind. 17. I will show them to you (m. and f. sing. and plur.).

Continued

FRENCH Continued from page 4218 **By Louis A. Barbé, B.A.**

VERBS—continued

Impersonal Verbs

1. Impersonal, or unipersonal verbs (*verbes impersonnels ou unipersonnels*) are intransitive verbs used only in the third person singular, or in the infinitive and participles, which are not personal tenses.

2. The following verbs are always impersonal:

Infinitive	*Indicative Present*
pleuvoir, to rain	*il pleut*, it rains
neiger, to snow	*il neige*, it snows
grêler, to hail	*il grêle*, it hails
tonner, to thunder	*il tonne*, it thunders
geler, to freeze	*il gèle*, it freezes
dégeler, to thaw	*il dégèle*, it thaws
bruiner, to drizzle	*il bruine*, it drizzles
venter, to be windy	*il vente*, it is windy
importer, to matter	*il importe*, it matters
falloir, to be necessary	*il faut*, it is necessary

3. There are a great many verbs which, though not essentially impersonal, are often used impersonally. Of these, the following occur most frequently:

Infinitive	*Indicative Present*
sembler, to seem	*il semble*, it seems
paraître, to appear	*il paraît*, it appears
convenir, to be suitable	*il convient*, it is suitable
arriver, to happen	*il arrive*, it happens
s'agir de, to be the question	*il s'agit de*, the question is
se trouver, to be found	*il se trouve*, it is found

4. The third person singular of *être*, to be, is used to form impersonal expressions: *Il est vrai que je suis son ami*, It is true I am his friend. *Avoir*, preceded by *y*, is used impersonally, with the meaning of "to be": *Il y a un Dieu*, There is a God. *Faire*, to make, is used impersonally, with the meaning of "to be," in a number of expressions chiefly referring to the state of the weather: *Il fait beau*, It is fine; *Il fait mauvais temps*, It is bad weather; *Il fait froid*, It is cold.

Pleuvoir, to rain

Principal Parts: *Pleuvoir, pleuvant, plu, il pleut, il plut.*

INDICATIVE

SIMPLE TENSES	COMPOUND TENSES
Present	*Past Indefinite*
il pleut, it rains	*il a plu*, it has rained
Imperfect	*Pluperfect*
il pleuvait, it was raining	*il avait plu*, it had rained
Past Definite	*Past Anterior*
il plut, it rained	*il eut plu*, it had rained
Future	*Future Anterior*
il pleuvra, it will rain	*il aura plu*, it will have rained

CONDITIONAL

Present	*Past*
il pleuvrait, it would rain	*il aurait plu*, it would have rained

SUBJUNCTIVE

Present
qu'il pleuve, that it may rain

Past
qu'il ait plu, that it may have rained

Imperfect
qu'il plût, that it might rain

Pluperfect
qu'il eût plu, that it might have rained

Falloir, to be necessary

Principal Parts: *falloir* (no pres. part.), *fallu*, *il faut, il fallut.*

INDICATIVE

SIMPLE TENSES	COMPOUND TENSES
Present	*Past Indefinite*
il faut, it is necessary	*il a fallu*, it has been necessary
Imperfect	*Pluperfect*
il fallait, it was necessary	*il avait fallu*, it had been necessary
Past Definite	*Past Anterior*
il fallut, it was necessary	*il eut fallu*, it had been necessary
Future	*Future Anterior*
il faudra, it will be necessary	*il aura fallu*, it will have been necessary

CONDITIONAL

Present	*Past*
il faudrait, it would be necessary	*il aurait fallu*, it would have been necessary

SUBJUNCTIVE

Present	*Past*
qu'il faille, that it may be necessary	*qu'il ait fallu*, that it may have been necessary
Imperfect	*Pluperfect*
qu'il fallût, that it might be necessary	*qu'il eût fallu*, that it might have been necessary

Uses of Falloir. 1. *Falloir* is frequently equivalent to the English verb "must." In that case the subject of "must" becomes the subject of the following verb, which requires to be in the subjunctive: *Il faut que je réponde à sa lettre*, I must answer his letter; *Il faut que les enfants soient obéissants*, Children must be obedient.

2. When the statement made is general, or when the person on whom the obligation falls is sufficiently indicated by the context, the second verb may be in the infinitive: *Il faut obéir aux lois*, We must obey the laws; *Mes enfants, il faut vous coucher*, Children, you must go to bed

3. With the infinitive construction, the person indicated by the subject of "must" may be indicated by an indirect object, or dative: *Il me faut sortir*, I must go out.

This construction is not, however, a very common one, and can be used with a pronoun only, not with a noun.

4. In the past and future, *falloir* cannot be translated in English by "must," but may be

rendered by the suitable tenses of "to have to." *Il faudra nous dépêcher,* We shall have to make haste; *Il a fallu qu'il me le donnât,* He had to give it to me.

5. When *falloir* is followed by a noun, it means "to want," "to require." In that case, the subject of the English verb is expressed by an indirect object, or dative, and is placed before *falloir*, if it be a personal or relative pronoun, but after it if it be a noun: *Il me faut d'autres livres,* I require other books; *Voici l'élève à qui il faut une grammaire,* Here is the pupil who requires a grammar; *Il faut une nouvelle robe à ma sœur,* My sister requires a new dress.

6. *Falloir* is used idiomatically in the following expressions:

(*a*) *S'en falloir de beaucoup,* To be far from; *Il s'en faut de beaucoup que la somme y soit,* The sum is far from being complete; *Il ne s'en faut pas de beaucoup que la somme n'y soit,* The sum is not far from being complete (lit., from being there).

(*b*) *S'en falloir de peu,* or *peu s'en falloir,* not to be far from, to want but little, to be near. *Peu s'en fallut qu'il n'en mourût,* He was near dying of it.

(*c*) *Tant s'en faut,* so far from, far from it, by a long way. *Tant s'en faut qu'il consente, qu'au contraire il fera tout pour l'empêcher,* He is so far from consenting, that, on the contrary, he will do everything to prevent it; *Ils ne nous ont pas payé tout ce qu'ils nous devaient; tant s'en faut,* They have not paid us all they owed us; far from it (by a long way).

7. *Comme il faut* (pronounced ko-mi-fô) is used as a qualificative, with the meaning of "respectable," "gentlemanly," "ladylike"; and also as an adverbial phrase signifying "suitably," "properly": *Ce sont des gens très comme il faut,* They are very respectable people; *C'est un homme tout à fait comme il faut,* He is quite a gentleman. *Elle a l'air très comme il faut,* She looks very ladylike.

Exercise XXX.

1. The earth is warmed (*échauffer*) by the sun.
2. The egoist (*égoïste*) is loved by (*de*) nobody.
3. Figures (*le chiffre*) were invented (*inventer*) by the Arabs (*Arabe*).
4. The woman was deceived by the serpent (*le serpent*).
5. Thunderstorms (*un orage*) are foreseen (*prévu*) and announced by the swallows.
6. America (*l'Amérique*) was discovered (*découverte*) by Christopher Columbus (*Christophe Colomb*) in 1492.
7. Printing (*l'imprimerie,* f.) was invented by Gutenberg in the fifteenth century.
8. The Cape of Good Hope (*le cap de Bonne-Espérance*) was doubled (*doubler*) for the first time by the Portuguese (*Portugais*).
9. When did you come back from Paris?
10. What day did your friends leave (*partis*) for London?
11. Since the comet (*la comète*) has (is) appeared (*apparue*) a crowd (*la foule*) of people pass the night (*à*) looking at it.
12. When we arrived at the station (*la gare*) the train (*le train*) had already started.
13. It seems that the sun turns (*tourner*) around (*autour de*) the earth, when, on the contrary (*au contraire*) it is certain that it is the latter which turns around the sun.
14. If it freezes (in) the morning, it is often fine all day (*journée,* f.).
15. A door must be open (*ouverte*) or closed, says a French proverb.
16. I have told you everything. What (of) more do you want?
17. That is just what I require; thanks (*merci*).
18. His friends are very respectable people.
19. He was very near being killed (*tuer*).
20. To (*pour*) speak well, it is necessary to say what is required, all that is required, nothing but (*rien que*) what is required, and to say it suitably.

IRREGULAR VERBS

Amongst the verbs classed as irregular there are some of which all the tenses are formed quite regularly from the principal parts, but in which these principal parts themselves present some peculiarities. As regards these verbs, it will be sufficient to give the principal parts, together with the three persons singular of the present indicative. No such verbs occur in the first conjugation, and the third has only two.

Second Conjugation. 1. Assaillir, to assail, *assaillant, assailli, j'assaille, tu assailles, il assaille, j'assaillis.* Some grammarians give an irregular future, *j'assaillerai,* instead of *j'assaillirai.*

2. Bouillir, to boil, *bouillant, bouilli, je bous, tu bous, il bout, je bouillis.* This verb is intransitive, and its use is consequently practically limited to the third person. "To boil" as a transitive verb is *faire bouillir,* "to make boil."

3. Couvrir, to cover, *couvrant, couvert, je couvre, tu couvres, il couvre, je couvris.*

4. Dormir, to sleep, *dormant, dormi, je dors, tu dors, il dort, je dormis.*

5. Fuir, to flee, *fuyant, fui, je fuis, tu fuis, il fuit, je fuis.*

6. Mentir, to tell a lie, *mentant, menti, je mens, tu mens, il ment, je mentis.*

7. Offrir, to offer, *offrant, offert, j'offre, tu offres, il offre, j'offris.*

8. Ouvrir, to open, *ouvrant, ouvert, j'ouvre tu ouvres, il ouvre, j'ouvris.*

9. Partir, to set out, *partant, parti, je pars, tu pars, il part, je partis.*

10. Sentir, to feel, to smell, *sentant, senti, je sens, tu sens, il sent, je sentis.* The reflexive verb *se repentir,* to repent, is conjugated like *sentir.*

11. Servir, to serve, *servant, servi, je sers, tu sers, il sert, je servis.*

12. Sortir, to go out, *sortant, sorti, je sors, tu sors, il sort, je sortis.*

13. Souffrir, to suffer, *souffrant, souffert, je souffre, tu souffres, il souffre, je souffris.*

14. Tressaillir, to start, to shudder, is conjugated like *assaillir.*

15. Vêtir, to clothe, *vêtant, vêtu, je vêts, tu vêts, il vêt, je vêtis.*

Third Conjugation. 3. Pourvoir, to provide, *pourvoyant, pourvu, je pourvois, tu pourvois, il pourvoit, je pourvus.*

2. Prévoir, to foresee, *prévoyant, prévu, je prévois, tu prévois, il prévoit, je prévis.*

EXERCISE XXXI.

1. Our brigade will attack (*assaillir*) the enemy in his retrenchments (*le retranchement*) to-morrow morning.

2. A few shots (*coups de feu*) are fired (go off); at this noise Napoleon starts. The Russian (*de Russie*) campaign (*la campagne*) is opened.

3. Everybody (*tout le monde*) knows (*sait*) that it was Christopher Columbus who discovered America.

4. He never opens his mouth without saying some foolish thing (*la sottise*).

5. The noise that was made (*se faisait*) in the meeting (*une assemblée*) covered the voice of the speaker (*orateur*).

6. It is certain that the sea formerly covered a great part of the inhabited (*habiter*) earth.

7. The water would boil more quickly if you lighted (*allumer*) a good fire.

8. Francis (*François*) I. slept on a gun-carriage (*un affût*) the night of the battle (*la bataille*) of Marignano (*Marignan*).

9. We fall asleep (*s'endormir*) every evening whilst he reads (*lit*) the paper (*le journal*) to us.

10. When we were young we used to sleep twelve hours without awakening (*se réveiller*).

11. Isaac having asked his father where the victim (*la victime*) was which was to be sacrificed (*immoler*), Abraham answered: "God will provide for (to) it."

12. Charles the Bold (*Téméraire*) perished (*périr*) before Nancy, betrayed (*trahir*) by a Neapolitan mercenary (*un mercénaire napolitain*) and killed whilst (*en*) fleeing after the battle by a gentleman of Lorraine (*gentilhomme lorrain*).

13. Let us flee together to the depths (*le fond*) of the forests; it is better to trust (*se fier*) to tigers than to men.

14. There are people (*gens*) who lie simply for the sake of (*pour*) lying.

15. Satire (*la satire*) lies about (on) men of letters (*gens de lettres*) during their life, and praise (*l'éloge*) lies after their death.

16. He has been offered a situation (*une place*) in Paris, but he does not wish (*désirer*) to leave (*quitter*) London.

17. It is useful for (to) the proud (*le superbe*) to fall, because their fall opens their eyes.

18. We (*on*) are usually (*ordinairement*) less grieved (*fâché*) when we go away than when we see (*voit*) (others) go away.

19. We ought to have started for the country yesterday, but we shall start to-morrow only.

20. When you (sing.) tell a lie, does not your conscience (*la conscience*) reproach (*reprocher*) you (with) something, and do you not repent immediately?

21. The judge who is faithful to his duty (*le devoir*) feels neither regrets (*le regret*) nor anger (*courroux*, m.).

22. There are people who seem to think (*croire*) that the happiness of serving them is a sufficiently (*assez*) high reward (*la récompense*) for those who serve them.

23. Go out when you like (*voudrez*), but I warn you (*avertir*) that I shall go out only after you (shall) have (be) gone out.

24. Is it worth while (*la peine*) to live (*vivre*) when we (one) suffer? Yes, for we always hope that we shall not suffer to-morrow.

25. The misfortune (*le malheur*) of those people who know all (it) is that they never foresee anything.

KEY TO EXERCISE XXIX.

1. Il me semble que j'ai déjà vu cette dame. Comment s'appelle-t-elle?

2. Les vaincus ne se sont pas moins bien battus que les vainqueurs.

3. L'ennemi s'est emparé de la ville après un long siège, pendant lequel les habitants se sont défendus aussi courageusement que les soldats.

4. Nous nous défions trop des autres, et nous ne nous méfions pas assez de nous-mêmes.

5. Il y a des hommes qui se glorifient plus de leurs défauts que de leurs bonnes qualités.

6. Aide-toi, le ciel t'aidera, dit le proverbe.

7. Elles se sont aperçues de leur erreur, mais il était trop tard.

8. Un écrivain a dit que si nous nous vantons souvent de ne point nous ennuyer, c'est parce que nous sommes si glorieux que nous ne voulons pas nous trouver de mauvaise compagnie.

9. A quelle heure vous levez-vous ordinairement? Nous nous levons ordinairement à sept heures, et nous nous couchons rarement avant onze heures et demie.

10. De grands motifs peuvent nous engager à nous humilier, aucun à nous avilir.

11. Les Romains, après s'être emparés de la Gaule, lui donnèrent en peu de temps leur civilisation.

12. Il vaut mieux s'exposer à l'ingratitude que de laisser sans secours un malheureux.

13. L'histoire nous dit qu'il y a eu des rois qui se sont dévoués à la mort pour le salut de leur peuple.

14. Il y a bien de la différence entre se plaire à un travail et y être propre.

15. Nous sommes si accoutumés à nous déguiser aux autres, qu'enfin nous nous déguisons à nous-mêmes.

16. Il est aussi facile de se tromper soi-même sans s'en apercevoir, qu'il est difficile de tromper les autres sans qu'ils s'en aperçoivent.

Continued

GERMAN

Continued from page 4222

By P. G. Konody and Dr. Osten

XCV. Principal Rules of German Punctuation. The full stop (.) is employed at the end of a complete sentence, and after inscriptions, abbreviations and numerals, as in English. Examples: Der Vater kommt heute. Er bat mich ihn zu besuchen, The father is coming to-day. He asked me to call on him, etc.; u. s. w. (abbreviation of und so weiter, and so forth); z. B. (zum Beispiel, for example); der 15. August.

The mark of interrogation (?) is put after an interrogative sentence; and the mark of exclamation (!) after expressions of command, desire,

joy, grief, and after addressing persons in letters (Lieber Freund! etc.).

The comma, the semicolon, the colon, and the full stop indicate pauses in the sentence. The shortest pause is denoted by the comma, the longest by the full stop. The use of the comma in German differs from the English. It is employed (*a*) in enumerations. Example: Männer, Frauen, Mädchen, Knaben eilten umher, Men, women, girls *and* boys were running about. (*b*) Between principal sentences and subordinate clauses. Examples: Er bat mich, daß ich kommen möge, He begged me to come. Dies ist der Mann, der mir den Weg zeigte, This is the man who showed me the way. (*c*) When a co-ordinate or subordinate clause contains a new subject and predicate. Examples: Der Vater sagte mir nichts, und auch die Mutter schwieg, Father said nothing to me, and mother, too, kept silent. (*d*) With quotations. Example: Hier bin ich, sagte er, Here I am, he said.

The semicolon and the colon are used for indicating longer pauses in complicated compound sentences, for the sake of the clearer articulation of the sentence; and the colon is also used to introduce enumerations.

All other signs are used exactly as in English.

XCVI. German Correspondence. The mode of address in German business letters differs from the English form in so far as it is customary to use only the name of the addressee's firm, and not the additional address of civility, „Sir," or „Dear Sir," or „Gentlemen". On the other hand the signature is frequently preceded by expressions of courtesy, which would sound ridiculous if literally translated into English: Hochachtungsvoll (full of high esteem); Ergebenst (most devotedly); Mit dem Ausdrucke aufrichtiger Wertschätzung (with the expression of sincere valuation); Mit der Versicherung vorzüglicher Hochachtung (with the assurance of excellent high esteem); etc. In private letters without distinct commercial character, the style of address is: Sehr geehrter Herr! Dear Sir (very honoured sir); Werte gnädige Frau! Dear Madam (esteemed gracious madam); Sehr geehrtes gnädiges Fräulein! Hochgeschätzte Frau! etc. This address is always followed by a note of exclamation. The signature is again preceded by the customary terms of courtesy, as in business letters. It is not considered very good form to begin private letters with the personal pronoun „Ich".

KEY TO EXERCISES IN EXAMINATION PAPER XXIII. (PAGES 4220–1)

EXERCISE 1 (*a*). Ich kaufte den Hut in dem Geschäfte, das (or welches) sich nebenan befindet. Dies widerfuhr mir, der ich doch, etc. Er stellte mir seine Frau vor, die (or welche) ich vorher, etc. Dies ist der Mann, dessen Sohn, etc. Dies ist die Bäuerin, deren Tochter, etc. Das war Alles, was ich erfahren konnte. Das sagen Sie, der dies doch besser wissen sollte? Das sagte der Mann, der (or welcher) dies hätte besser wissen müssen. Das Klügste, was wir tun können, ist, abzureisen. Es gab nichts, was er nicht wußte.

(*b*) Ich kaufte den Hut in dem Geschäfte, das sich nebenan befindet. Alle Mühe, die daran gewendet wurde, war vergeblich, or Alle Mühe war vergeblich, die daran, etc. Ich befolgte den Rat, der mir erteilt werden war (or wurde). Sie schenkte ihm eine Rose, welche wunderbar duftete. Er zeigte mir den Weg, welcher der kürzeste war.

EXERCISE 2. Ich fühlte mich so wohl, wie ein Fisch im Wasser. Ich fühlte mich wohler, als ein Fisch im Wasser. Wie die Sonne aus den Wolken bricht, so trat die Fee, etc. Unser Garten ist weit schöner als der seine. Er liebte ihn, wie ein Bruder den andern.

Private Letters.

Lieber Freund! Sehr geehrter Herr!	Dear Friend, Dear Sir,
Werteste gnädige Frau! Lieber Gustav! Liebste Karoline!	Dear Madam, Dear Gustave, Dear Caroline,
Zu meinem lebhaften Bedauern ist es mir infolge eines unvorhergesehenen Zwischenfalles unmöglich geworden, unsere Verabredung einzuhalten. Ich wäre trostlos, wenn dadurch in Ihre Einteilung eine Störung getragen würde, allein es ist mir beim besten Willen nicht möglich, an der Partie teilzunehmen. Ich hoffe, daß Sie eine angenehme Fahrt und einen zufriedenstellenden Aufenthalt haben werden.	To my greatest regret, unforeseen circumstances make it impossible for me to keep to our arrangement. I should be sorry if this were to upset your plans, but I cannot possibly make one of the party, much as I should like to do so. I hope that you will have a pleasant journey and a satisfactory holiday.
In alter Herzlichkeit	Most cordially yours,
. . . .	. . . .
Sehr geehrter Herr!	Dear Mr. . . . . . .,
Meine Frau und ich würden uns aufrichtig freuen, wenn Sie uns das Vergnügen machen wollten, mit uns am nächsten Sonntag, den 12., um 1 Uhr, zu speisen. Wir haben einige Freunde eingeladen, die es sich zur Ehre anrechnen werden, Ihre Bekanntschaft zu machen.	My wife and I would be delighted if you could give us the pleasure of dining with us next Sunday, the 12th, at 1 p.m. We have invited a few friends who will feel honoured to make your acquaintance.
In aufrichtiger Ergebenheit	Most sincerely yours,
. . . .	. . . .
Herren A. & B.!	Messrs. A. & B.,
In höflicher Erledigung (Beantwortung) Ihrer geschätzten (geehrten) Zuschrift vom 4. d. M. (dieses Monats) [vom 4. v. M. (vorigen Monats)] beehre ich mich, Ihnen mitzuteilen [anzuzeigen, Sie zu benachrichtigen, Sie in Kenntniß zu setzen], daß die mir zu-	In [courteous] reply to your favour [esteemed letter] of the 4th inst. [of the 4th ult.] I beg to [have the honour to] inform you that the goods forwarded to me are only partially up to sample. The sizes, as well as the quantities and qualities,

gemittelten Waren nur zum Teile mustergemäß sind. Sowohl die Maße, als auch die Nummern und die Qualitäten entsprechen nicht meiner Ihrem Reisenden erteilten Ordre de dato 2. Mai d. J. (dieses Jahres). In der Anlage [Beigeschlossen] finden Sie eine Kopie meines auf Grund Ihrer Muster erteilten Auftrages nebst Aufstellung der tatsächlich gelieferten Waren. Wollen Sie demnach umgehend das Fehlende nachliefern und über das Nichtbestellte und Muster-Ungemäße disponieren. Die Zahlung erfolgt naturgemäß erst, sobald die Ordre komplett und auftragsgemäß effektuirt ist.

Durch die Ungenauigkeit in der Ausführung meiner Bestellung sind mir Unannehmlichkeiten erwachsen und es wäre, wenn unsere Verbindung aufrecht erhalten werden soll, wünschenswert, wenn solche Irrtümer [Störungen] in Zukunft vermieden würden.

Ihren gesch. (geschätzten) Nachrichten entgegensehend
Hochachtungsvoll und ergebenst

do not conform to the order given by me to your traveller on the 2nd of May last. Enclosed you will find a copy of my order based on your samples, together with a list of the goods actually delivered. Will you [in accordance with this list] make up the deficiency and dispose of the goods not ordered? Payment will, of course, only follow when the delivery has been completed according to order.

The irregularity (inexactness) in the execution of my order has caused me some unpleasantness, and if our relations are to be continued (kept up) it would be desirable if such errors were avoided in future.

Awaiting the favour of your esteemed reply,
[I am]
Yours very truly,

Herren . . . . . .!

In den Besitz Ihrer gesch. Zuschrift vom . . . . . . gelangt, haben wir von der uns darin avisirten Entnahme von £287.16.10 o/ (Ordre) Brüder Hellwald & Co., Berlin, drei Monate à dato, Notiz genommen, und wir werden Ihre Ziehung zulasten Ihrer w. (werten) Rechnung zur Zeit einlösen.

Zu Ihren Diensten stets gerne bereit, zeichnen wir
Hochachtungsvoll

Messrs. . . . . . .

We beg to acknowledge receipt of your favour of the . . . . inst. in which you advise us of your draft on us of £287 16s. 10d. to the order of Brothers Hellwald & Co., Berlin, three months from date, which will be duly honoured and debited to your account.

[Always at your service] we remain
Yours very truly,

Herren P. Winkelmann & Co., Berlin.

Von der Deutschen Bank in Berlin ist uns heute für Ihre w. Rechnung ein Check £648.14.11 zugegangen, den wir zum Ausgleiche Ihres Kontos verwendet haben. Ihren gefälligen weiteren Aufträgen mit Vergnügen entgegensehend, zeichnen wir
Hochachtungsvoll

Messrs. P. W. & Co., Berlin.

We have received to-day from the Deutsche Bank, Berlin, a cheque £648 14s. 11d. in full settlement of your account. Anticipating the favour of your further esteemed orders,
We are,
Yours faithfully,

. . . .

Herrn Dr. chem. Josef Lippmann, Frankfurt a. M.

Wir empfingen Ihr geschätztes Offert vom . . . . und sind nicht abgeneigt, der Frage Ihres Engagements für unsere Fabriken näher zu treten. Wie aus den uns zugemittelten Zeugnissen ersichtlich, haben Sie in unserer Spezial-Branche schon gearbeitet, und demnach dürfte Ihre Qualifikation für die Bedürfnisse unseres Betriebes im Großen und Ganzen außer Zweifel stehen. Abgesehen von der Honorirung, die den Gegenstand weiterer Verhandlungen zwischen uns zu bilden hätte, scheint uns die Frage von der Dauer des Engagements von besonderer Wichtigkeit. Wir legen auf eine drei- bis fünfjährige Engagements-Dauer Gewicht und erbitten uns Ihre freundliche Mitteilung, ob Sie geneigt sind, sich für eine derartige Periode zu verpflichten. Die in Ihrem Offertschreiben dargelegten Wünsche hinsichtlich der Ihnen beizustellenden wissenschaftlichen Laboratoriums-Behelfe etc. werden nach Tunlichkeit Berücksichtigung finden.

Hochachtungsvoll und ergebenst

Dr. Josef Lippmann, Frankfurt-a.-M.

We are in receipt of your esteemed application of the . . . . inst., and are not disinclined to consider the question of your engagement for our factories. It appears, from the testimonials you have sent us, that your qualifications for the requirements of our works appear to be on the whole beyond doubt. Apart from the question of salary, which would have to be discussed at a later date, the duration of the engagement seems to us an essential point. We attach great importance to a three to five years' engagement, and shall be glad if you will kindly let us know whether you feel disposed to bind yourself for this term. We shall give due consideration to the wishes expressed in your application regarding the scientific appliances to be supplied by us.

Yours very truly,

. . . .

Herren . . . . .

Ihren werten Auftrag de dato . . . ., können wir zu unserem Bedauern erst in der zweiten Hälfte des nächsten Jahres ausführen, da der Aufschwung in der Textilwaren-Industrie im Inlande unsere Produktion bis zu diesem Zeitpunkte vollständig in Anspruch

Messrs. . . . . . .

We are sorry to inform you that your esteemed order of . . . . . . cannot be executed before the second half of next year, as the boom in the textile industry for home consumption will fully absorb our output up to that date. Should your

nimmt. Falls Ihr Bedarf nicht unmittelbare Deckung nötig macht, wird es uns freuen, Ihnen ab Ende Juni 1907 dienlich sein zu können.

Ihrer gef. Meinungsäußerung entgegensehend
Hochachtungsvoll und ergebenst

. . . .

Herren . . . . .

Mit Gegenwärtigem erlauben wir uns die ergebene Anfrage, ob Sie in der Lage wären, den Ihnen mit separater Postsendung zugehenden Artikel in größeren Quantitäten herzustellen. Wir erbitten uns in diesem Falle Gegenmuster mit genauester Berechnung des Preises und Angabe des Liefertermines. Wir haben in diesem Artikel einen bedeutenden Umsatz und könnten konvenirenden Falles große Ordres erteilen. Wir legen, wie jetzt schon ausdrücklich erwähnt werden mag, auf strikteste Einhaltung der Qualität nach Muster, sowie auf prompte Lieferung das größte Gewicht. Die Zahlung erfolgt gegen Ladeschein.

Ihrer freundl. postwendenden Verständigung entgegensehend Hochachtungsvoll und ergebenst

. . . .

Herren S. Winkler & Co., Leipzig.

In höfl. Beantwortung Ihrer Anzeige in der Deutschen Handels-Zeitung vom . . . . . erlaube ich mir hierdurch, Ihnen meine Dienste als englischer Korrespondent anzubieten. Ich habe, wie Sie aus den beifolgenden Abschriften meiner Zeugnisse gütigst ersehen wollen, in deutschen Häusern als englischer Korrespondent bereits serviert und bin beider Sprachen in Wort und Schrift vollkommen mächtig.

Ihrer geschätzten Meinungsäußerung sieht entgegen
Hochachtungsvoll und ergebenst

. . . .

demand not require immediate supply, we shall be pleased to be at your service after the end of June, 1907.

In anticipation of your esteemed reply,
We are, Yours very truly,

. . . .

Dear Sirs,

We take the liberty of asking you whether you are in a position to produce large quantities of the article sent to you in a separate parcel, in which case we shall be glad to receive sample with lowest quotations and date of delivery. We have a large turn-over in this line, and are in a position to place large orders if suited We may mention at once that we attach the greatest importance to the goods being up to sample, and to prompt delivery. Payment on bill of lading.

Awaiting your reply by return of post,
We are,
Yours very truly,

. . . .

Messrs. S. Winkler & Co., Leipzig.
Gentlemen,

In reply to your Advertisement in the "Deutsche Handels-Zeitung" of the . . . . . I beg to offer you my services as English correspondent. As you may see from the enclosed copies of my testimonials, I have already served with German firms as English correspondent, and can speak and write both languages fluently.

In anticipation of your esteemed reply,
I am, Yours very truly,

. . . .

Concluded

SPANISH

Continued from page 4221

By Amalia de Alberti & H. S. Duncan

IRREGULAR VERBS

The Spanish irregular verbs are very numerous, but excepting a few, which are not classifiable, they may be divided into several classes, following easily definable rules.

Class I. Verbs of this class expand the radical vowels *e* and *o* into *ie* and *ue* when the stress falls upon them and not upon the verbal ending. The radical vowel is that which lies nearest the end of the verb stem, found by suppressing the infinitive ending; thus, in *acord-ar*, to agree, the radical vowel is *o*, which becomes *ue* whenever the stress is laid upon it. In all these verbs the accent falls on the radical vowel throughout the Indicative Present, the Subjunctive Present, and the Imperative, always excepting the first and second persons plural. In all other tenses, the accent falls on the verbal ending, so that, with the above exceptions, these verbs follow the rule of their regular conjugation. Examples:

Cerrar, to shut

Ind. Pres.—cierro, cierras, cierra, cerramos, cerrais, cierran.

Subj. Pres.—cierre, cierres, cierre, cerrémos, cerreis, cierren.

Imperat.—cierra, cierre, cerremos, cerrad, cierren.

Perder, to lose

Ind. Pres.—pierdo, pierdes, pierde, perdemos, perdeis, pierden.

Subj. Pres.—pierda, pierdas, pierda, perdamos, perdais, pierdan.

Imperat.—pierde, pierda, perdamos, perded, pierdan.

Acordar, to agree

Ind. Pres.—acuerdo, acuerdas, acuerda, acordamos, acordais, acuerdan.

Subj. Pres.—acuerde, acuerdes, acuerde, acordemos, acordeis, acuerden.

Imperat.—acuerda, acuerde, acordemos, acordad, acuerden.

Morder, to bite

Ind. Pres.—muerdo, muerdes, muerde, mordemos, mordeis, muerden.

Subj. Pres.—muerda, muerdas, muerdas, mordamos, mordais, muerdan.

Imperat.—muerde, muerda, mordamos, morded, muerdan.

Remarks. All verbs of this class observe the euphonic changes in spelling already given for the regular verbs. Thus, *rogar* (to beseech), besides expanding *o* into *ue*, follows the ordinary

rule for verbs ending in *gar*, changing the *g* into *gü* before *e*, thus:

Ind. Pres.—ruego, ruegas, ruega, rogámos, etc.

Subj. Pres.—ruegue, ruegues, ruegue, roguemos, roguéis, rueguen.

Imperat.—ruega, ruegue, roguemos, rogad, rueguen.

When in verbs of this class the radical vowel *o* is preceded by *g*, the expansion into *ue* takes a diæresis wherever it occurs. Example:

Degollar, to behead. *Ind. Pres.—degüello, degüellas, degüella, degollámos, degollais, degüellan.*

The verbs *oler*, to smell; *desosar*, to bone; and *desovar*, to spawn, take an *h* wherever the *o* is expanded into *ue*, thus:

Ind. Pres.—huelo, hueles, huele, olemos, oleis, huelen.

In the verb *errar*, to miss, wherever the *e* is expanded into *ie*, *i* becomes the initial letter, and is therefore written and pronounced *y*, thus:

Ind. Pres.—yerro, yerras, yerra, erramos, errais, yerran.

Note. *I* is also changed into *y* in other verbs when the stress falls upon the verbal termination beginning with the diphthongs *ie* or *io*. Example: *creer*, to believe; *creyendo*, believing.

The verb *jugar*, to play, formerly spelt with an *o*, is included in this class.

Class II. This class consists of verbs of the third conjugation only, with the radical vowels *e* and *o*.

Besides expanding these vowels into *ie* and *u* when the stress falls upon them, these verbs shorten *ie* and *ue* into *i* and *u* in the first and second persons plural of the Subjunctive Present, the first person plural of the Imperative, and throughout the conjugation whenever the verbal ending contains the diphthongs *ie* or *io*. Example:

Sentir, to feel; Gerund, *sintiendo*

Ind. Pres.—siento, sientes, siente, sentimos, sentís, sienten.

Past Def.—sentí, sentiste, sintió, sentimos, sentisteis, sintieron.

Imperat.—siénte, siénta, sintámos, sentid, sientan.

Subj. Pres.—sienta, sientas, siénta, sintamos, sintáis, siéntan.

Subj. Impf. (1) *sintiera, sintieras, sintiera, sintiéramos, sintiérais, sintieran.*
„ „ (2) *sintiese, sintieses, sintiese, sintiésemos, sintiéseis, sintiesen.*

Subj. Fut.—sintiere, sintieres, sintiere, sintiéremos, sintiéreis, sintieren.

The imperfect and future of the Indicative and the Conditional are regular.

Dormir, to sleep. Gerund, *durmiendo*

Ind. Pres.—duermo, duermes, duerme, dormimos, dormís, duermen.

Past Def.—dormí, dormiste, durmió, dormimos, dormísteis, durmieron.

Imperat.—duerme, duerma, durmamos, dormid, duerman.

Subj. Pres.—duerma, duermas, duerma, durmamos, durmais, duerman.

Subj. Impf. (1) *durmiera, durmieras, durmiera, etc.*
„ „ (2) *durmiese, durmieses, durmiese, etc.*

Subj. Fut.—durmiere, durmieres, durmiere, durmieremos, etc.

Note. A few verbs of the third conjugation ending in *quirir*, expand the radical *i* into *ie* when the accent falls on it, but are otherwise regular. Example:

Adquirir, to obtain. *Ind. Prés.—adquiero, adquieres, adquiere, adquirimos, adquiris, adquieren.*

The following is a list of the irregular verbs of the first class likely to be required in ordinary use:

First Class

Verbs with radical *e* expanding to *ie*, and radical *o* expanding to *ue*.

absolver, to absolve
acordar, to agree
acostar, to put to bed
acrecentar, to increase
alentar, to encourage
almorzar, to breakfast
alongar, to lengthen
amueblar, to furnish
amolar, to grind
apretar, to press
aprobar, to approve
arrendar, to rent
ascender, to ascend
asosegar, to calm
atender, to attend
atraer, to attract
atravesar, to cross over
avergonzar, to shame
calentar, to warm
cegar, to blind
cimentar, to lay a foundation
cocer, to cook
colgar, to hang up
comenzár, to commence
componer, to compose
comprobar, to prove
concertar, to concert
concordar, to agree
condescender, to condescend
condolerse, to condole
confesar, to confess
conmover, to move
consolar, to console
contar, to count
contender, to contend
costar, to cost
defender, to defend
demoler, to demolish
demostrar, to demonstrate
denegar, to deny
desacertar, to mistake
desacordar, to disagree
desalentar, to discourage
desapretar, to loose
desaprobar, to disapprove
desasosegar, to disturb
desatender, to neglect
desatentar, to perplex
descender, to descend
desenterrar, to unearth
deshelar, to thaw
desmentir, to give the lie
desolar, to desolate
despoblar, to depopulate
desterrar, to exile
desvergonzarse, to become shameless
detener, to detain
devolver, to give back
discordar, to disagree
disolver, to dissolve
despertar, to awake
doler, to ache
empellar, to impel
empezar, to begin
encender, to light
encentar, to cut
encerrar, to shut up
encomendar, to commend
encontrar, to meet
enmendar, to correct
enterrar, to bury
envolver, to wrap up
esforzar, to endeavour
extender, to extend
forzar, to force
fregar, to scour
gobernar, to govern
helar, to freeze
herrar, to shoe a horse
holgar, to rest
invernar, to winter
jugar, to play
llover, to rain
manifestar, to manifest
moler, to grind
mostrar, to show
mover, to move
negar, to deny
nevar, to snow
pensar, to think
perder, to lose
plegar, to fold
poblar, to populate
probar, to prove
proponer, to propose
quebrar, to break
recomendar, to recommend
recordar, to remember
reforzar, to fortify
regar, to water
remendar, to mend
remorder, to cause remorse
reprobar, to reprove
reventar, to burst
revolver, to stir
rodar, to roll
sembrar, to sow
sementar, to sow
sentarse, to sit down
sentar, to establish
sonar, to sound
soñar, to dream
sosegar, to calm
temblar, to tremble
tender, to stretch out
tentar, to tempt
tostar, to toast
transcender, to transcend
transponer, to transpose
trascordarse, to forget
travesar, to cross
trocar, to exchange
tronar, to thunder
tropezar, to stumble
verter, to spill
volar, to fly
volver, to come back.

Note. Only one meaning is given here; a good dictionary should be consulted for the further meanings of each verb.

Second Class

Verbs of the third conjugation with radical *e* and *o*, expanding to *ie* and *ue*, or changing to *i* and *u*:

adherir, to adhere	***ingerir***, to interfere
adormirse, to fall asleep	***invertir***, to invert
asentir, to assent	***malherir***, to wound badly
conferir, to confer	***morir***, to die
convertir, to convert	***pervertir***, to pervert
deferir, to defer (show deference)	***preferir***, to prefer
desadvertir, to act rashly	***premorir***, to predecease
diferir, to defer (put off)	***proferir***, to pronounce
digerir, to digest	***referir***, to refer
discernir, to discern	***reherir***, to repel
disentir, to dissent	***reherrar***, to re-shoe (a horse)
divertir, to divert	***rementir***, to lie frequently
entregerir, to intermix	***sentir***, to feel
entremorir, to die away	***subvertir***, to subvert
herir, to wound	***sugerir***, to suggest
hervir, to boil	***transferir***, to transfer
inferir, to infer	***zaherir***, to censure

Exercise XV. (1)

Translate the following into Spanish:

1. We have shut all the doors; now you shut the windows.

2. It is not worth while to beseech them to pardon him; you beseech, if you like.

3. The smell of those flowers is a real perfume.

4. It is difficult to acquire fame, and even more difficult to preserve it after it is acquired.

5. It is well to encourage youth; I always encourage it.

6. It is difficult to approve when a friend criticises us with truth; the approbation of those who surround us is necessary to our happiness.

7. It is necessary to attend to our business.

8. Let us be careful in crossing the square; I cross it always looking to the right and to the left.

9. The proverb says that there is no one more blind than he who will not see. To be blind to our defects is natural.

10. The foundation of our friendship was laid years ago when we suffered together. Troubles are calculated to lay the foundation of friendly intercourse.

11. This room needs to be warmed, and the breakfast must also be warmed.

Exercise XV. (2)

Translate the following into English:

1. El destierro politico á que fué condenado hizo su fortuna, cuando su partido volvió al poder.

2. Despertar la ira de una persona apasionada es peligroso, una vez despierta es difícil de apaciguar.

3. Es mas difícil al hombre gobernar sus pasiones que gobernar una nacion.

4. Niego absolutamente haber dicho semejante cosa, y cuando me confronten con él no lo podrá negar.

5. Se dice que mas vale remendar su capa á tiempo, que dejar que el remiendo sea mas grande que la capa.

6. El que siembra espinas no puede esperar que salgan flores, mas vale sembrar buena semilla que sementar abrojos.

7. El tonto sueña loque quiere, y el sabio lo que puede. El soñar no se manda.

Key to Exercise XIV. (1)

1. ¿Quiere Vd jugar al ajedrez? No sé jugar tan bien como Vd. No importa, le daré la reina y el peon.

2. Muy bien; pero despues de concluido el juego de ajedrez, tendrémos uno de damas. Creo que conozco ese juego más bien. Aquí está el tablero.

3. Tome Vd un cigarro; son buenos; son habanos. Gracias, no fumo. ¿Y su hermano fuma? Mi hermano fuma cigarros, cigarillos, y la pipa.

4. Los escoséses tocan la gaita, y son los únicos en el mundo entero que pueden tocarla.

5. Esa agua que vé Vd aqui es un manantial de agua dulce.

6. Este es un arroyo en verano, y un rió caudaloso en invierno.

7. La calma viene antes de la tormenta.

8. ¡Dice que es buen jinete, y no sabe manejar su caballo!

9. ¿Usa Vd espuelas? Nunca.

10. Esa silla es vieja. Deberia Vd comprar otra nueva y permítame que le diga que los estribos son demasiado largos.

11. Ese caballo es muy brioso; necesita domarse. Eso es fácil; tengo en mi caballeriza un buen picador.

12. El aparejar se hará pronto.

13. No es bueno alabarse tanto, pues el que se alaba corre el riesgo de que se burlen de él.

14. ¡Dejárlos burlarse; no me importa!

15. Se me alegra el corazon al ver á Vd.

16. Nos alegrámos mucho de su buena fortuna.

Key to Exercise XIV. (2)

1. The war was very sanguinary; many soldiers died.

2. On receiving the sad news the poor woman fainted.

3. May I open that letter? It has been opened since this morning.

4. The sky is overcast; they must cover the flowers, as it will surely rain.

5. I have written to your father giving him news of our engagement: we shall see if he deigns to write.

6. Those words are printed on my heart.

7. This manuscript must be printed.

8. America was discovered by Columbus.

9. Upon discovering the statue, they threw it on the ground.

10. It thunders, rains and freezes at the same time.

11. It is going to thunder.

12. We left the town incognito at dawn.

13. Day breaks at five in the morning.

14. We reached our destination at nightfall; it was a long journey.

15. Is it true that it is twelve miles from here to San Juan de Luz?

Continued

End of Volume V.